SCIENCE

FRIDAY, MARCH 26, 1915

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

GRADUATE MATHEMATICAL INSTRUCTION FOR GRADUATE STUDENTS NOT INTENDING TO BECOME MATHEMATICIANS[1]

IN his "Annual Report" under date of November last, the President of Columbia University speaks in vigorous terms of what he believes to be the increasing failure of present-day advanced instruction to fulfil one of the chief purposes for which institutions of higher learning are established and maintained.

President Butler, in the course of an interesting section devoted to college and university teaching, says:

> A matter that is closely related to poor teaching is found in the growing tendency of colleges and universities to vocationalize all their instruction. A given department will plan all its courses of instruction solely from the point of view of the student who is going to specialize in that field. It is increasingly difficult for those who have the very proper desire to gain some real knowledge of a given topic without intending to become specialists in it. A university department is not well organized and is not doing its duty until it establishes and maintains at least one strong substantial university course designed primarily for students of maturity and power, which course will be an end in itself and will present to those who take it a general view of the subject-matter of a designated field of knowledge, its methods, its literature and its results. It should be possible for an advanced student specializing in some other field to gain a general knowledge of physical problems and processes without becoming a physicist; or a general knowledge of chemical problems and processes without becoming a chemist; or a general knowledge of zoological problems and processes without becoming a zoologist; or a general

[1] An address delivered before Section A of the American Association for the Advancement of Science, December 30, 1914.

knowledge of mathematical problems and processes without becoming a mathematician.

This is a large matter, involving all the cardinal divisions of knowledge. I have neither time nor competence to deal with it fully or explicitly in all its bearings. As indicated by the title of this address it is my intention to confine myself, not indeed exclusively but in the main, to consideration of the question in its relation to advanced instruction in mathematics. The obvious advantages of this restriction will not, I believe, be counterbalanced by equal disadvantages. For, much as the principal subjects of university instruction differ among themselves, it is yet true that as instruments of education they have a common character and for their efficacy as such depend fundamentally upon the same educational principles. A discussion, therefore, of an important and representative part of the general question will naturally derive no little of whatever interest and value it may have from its implicit bearing upon the whole. It is not indeed my intention to depend solely upon such implicit bearings nor upon the representative character of mathematics to intimate my opinion respecting the question in its relation to other subjects. On the contrary, I am going to assume that specialists in other fields will allow me, as a lay neighbor fairly inclined to minding his own affairs, the privilege of some quite explicit preliminary remarks upon the larger question.

I suspect that my interest in the matter is in a measure temperamental; and my conviction in the premises, though it is not, I believe, an unreasoned one, may be somewhat colored by inborn predilection. At all events I own that a good many years of devotion to one field of knowledge has not destroyed in me a certain fondness for avocational studies, for books that deal with large subjects in large ways, and for men who, uniting the generalist with the specialist in a single gigantic personality, can show you perspectives, contours and reliefs, a great subject or a great doctrine in its principal aspects, in its continental bearings, without first compelling you to survey it pebble by pebble and inch by inch. I can not remember the time when it did not seem to me to be the very first obligation of universities to cherish instruction of the kind that is given and received in the avocational as distinguished from the vocational spirit—the kind of instruction that has for its aim, not action but understanding, not utilities but ideas, not efficiency but enlightenment, not prosperity but magnanimity. For without intelligence and magnanimity—without light and soul—no form of being can be noble and every species of conduct is but a kind of blundering in the night. I could hardly say more explicitly that I agree heartily and entirely with the main contention of President Butler's pronouncement. Indeed I should go a step further than he has gone. He has said that a university *department* is not well organized and is not doing its duty until it establishes and maintains the kind of instruction I have tried to characterize. To that statement I venture to add explicitly—what is of course implicit in it—that a *university* is not well organized and is not doing *its* duty until it makes provision whereby the various departments are enabled to foster the kind of instruction we are talking about. That in all major subjects of university instruction there ought to be given courses designed for students of "maturity and power" who, whilst specializing in one subject or one field, desire to generalize in others, appears to me to be from every point of view so reasonable and just a proposition that it would not occur to me to regard it as questionable or debatable were it not for the fact that it actually is questioned and debated by teachers of eminence and authority.

What is there in the contention about which men may differ? Dr. Butler has said that there is a "growing tendency of college and university departments to vocationalize all their instruction." Is the statement erroneous? It may, I think, be questioned whether the tendency is growing. I hope it is not. Of course specialization is not a new thing in the world. It is far older than history. Let it be granted that it is here to stay, for it is indispensable to the advancement of knowledge and to the conduct of human affairs. Every one knows that. There is, however, some evidence that specialization is becoming, indeed that it has become, wiser, less exclusive, more temperate. The symptoms of what not long ago promised to become a kind of specialism mania appear to be somewhat less pronounced. Recognition of the fact that specialization is in constant peril of becoming so minute and narrow as to defeat its own ends is now a commonplace among specialists themselves, many of whom have learned the lesson through sad experience, others from observation. Specialists are discoverers. One of our recent discoveries is the discovery of a very old truth: we have discovered that no work can be really great which does not contain some element or touch of the universal, and that is not exactly a new insight. Leonardo da Vinci says:

> We may frankly admit that certain people deceive themselves who apply the title "a good master" to a painter who can only do the head or the figure well. Surely it is no great achievement if by studying one thing only during his whole lifetime he attain to some degree of excellence therein!

The conviction seems to be gaining ground that in the republic of learning the ideal citizen is neither the ignorant specialist, however profound he may be, nor the shallow generalist, however wide the range of his interest and enlightenment. It is not important, however, in this connection to ascertain whether the vocationalizing tendency is at present increasing or decreasing or stationary. What is important is to recognize the fact that the tendency, be it waxing or waning, actually exists, and that it operates in such strength as practically to exclude all provision for the student who, if I may so express it, would qualify himself to gaze into the heavens intelligently without having to pursue courses designed for none but such as would emulate a Newton or a Laplace. If any one doubts that such is the actual state of the case, the remedy is very simple: let him choose at random a dozen or a score of the principal universities and examine their bulletins of instruction in the major fields of knowledge.

Another element—an extremely important element—of President Butler's contention is present in the form of a double assumption: it is assumed that in any university community there are serious and capable students whose primary aim is indeed the winning of mastery in a chosen field of knowledge but who at the same time desire to gain some understanding of other fields—some intelligence of their enterprises, their genius, their methods and their achievements; it is further assumed that this non-vocational or avocational propensity is legitimate and laudable. Are the assumptions correct? The latter one involves a question of values and will be dealt with presently. In respect of the former we have to do with what mathematicians call an existence theorem: Do the students described exist? They do. Can the fact be demonstrated—deductively proved? It can not. How, then, may we know it to be true? The answer is: partly by observation, partly by experience, partly by inference and partly by being candid with ourselves. Who is there among us that is unwilling to admit that he himself now is or at least once was a student of the kind?

Where is the university professor to whom such students have not revealed themselves as such in conversation? Who is it that has not learned of their existence through the testimony of others? No doubt some of us not only have known students of the kind, but have tried in a measure to serve them. We may as well be frank. I have myself for some years offered in my subject a course designed in large part for students having no vocational interest in mathematics. I may be permitted to say, for what the testimony may be worth, that the response has been good. The attendance has been composed about equally of students who were not looking forward to a career in mathematics and of students who were. And this leads me to say, in passing, that, if the latter students were asked to explain what value such instruction could have for them, they would probably answer that it served to give them some knowledge *about* a great subject which they could hardly hope to acquire from courses designed solely to give knowledge *of* the subject. Every one knows that it often is of great advantage to treat a subject as an object. One of the chief values of n-dimensional geometry is that it enables us to contemplate ordinary space from the outside, as even those who have but little imagination can contemplate a plane because it does not immerse them. Returning from this digression, permit me to ask: if, without trying to discover the type of student in question, we yet become aware, quite casually, that the type actually exists, is it not legitimate to infer that it is much more numerously represented than is commonly supposed? And if such students occasionally make their presence known even when we do not offer them the kind of instruction to render their wants articulate, is it not reasonable to infer that the provision of such instruction would have the effect of revealing them in much greater numbers?

Indeed it does not seem unreasonable to suppose that a "strong substantial course" of the kind in question, in whatever great subject it were given, would be attended not only by considerable numbers of regular students but in a measure also by officers of instruction in other subjects and even perhaps by other qualified residents of an academic community. Only the other day one of my mathematical colleagues said to me that he would rejoice in an opportunity to attend such a course in physics. The dean of a great school of law not long ago expressed the wish that some one might write a book on mathematics in such a way as would enable students like himself to learn something of the innerness of this science, something of its spirit, its range, its ways, achievements and aspiration. I have known an eminent professor of economics to join a beginners' class in analytical geometry. Very recently one of the major prophets of philosophy declared it to be his intention to suspend for a season his own special activity in order to devote himself to acquiring some knowledge of modern mathematics. Similar instances abound and might be cited by any one not only at great length, but in connection with every cardinal division of knowledge. Their significance is plain. They are but additional tokens of the fact that the race of catholic-minded men has not been extinguished by the reigning specialism of the time, but that among students and scholars there are still to be found those whose curiosity and intellectual interests surpass all professional limits and crave instruction more generic in kind, more liberal, if you please, and ampler in its scope, than our vocationalized programs afford.

As to the question of values, I maintain

that the desire of such men is entirely legitimate, that it is wholesome and praiseworthy, that it deserves to be stimulated, and that universities ought to meet it, if they can. Indeed, all this seems to me so obvious that I find it a little difficult to treat it seriously as a question. If the matter must be debated, let it be debated on worthy ground. To say, as proponents sometimes say, that, inasmuch as all knowledge turns out sooner or later to be useful, students preparing for a given vocation by specializing in a given field may profitably seek some general acquaintance with other fields *because* such general knowledge will indirectly increase their vocational equipment, is to offer a consideration which, though in itself it is just enough, yet degrades the discussion from its appropriate level, which is that of an ideal humanity, down to the level of mere efficiency and practicianism. No doubt one engaged in minutely studying the topography of a given locality because he intends to reside in it might be plausibly advised to study also the general geography of the globe on the ground that his special topographical knowledge would be thus enhanced, and that, moreover, he might some time desire to travel. But if we ventured to counsel him so, he might reply: What you say is true. But why do you ply me with such low considerations? Why do you regard me as something crawling on its belly? Don't you know that I ought to acquire a general knowledge of geography, not primarily because it may be useful to me as a resident here or as a possible traveler, but because such knowledge is essential to me in my character as a man? The rebuke, if we were fortunately capable of feeling it, would be well deserved. A man building a bridge is greater than the engineer; a man planting seed is greater than the farmer; a man teaching calculus is greater than the mathematican; a man presiding at a faculty meeting is greater than the dean or the president. We may as well remember that man is superior to any of his occupations. His supreme vocation is not law or medicine or theology or commerce or war or journalism or chemistry or physics or mathematics or literature or any specific science or art or activity; it is intelligence, and it is this supreme vocation of man as man that gives to universities their supreme obligation. It is unworthy of a university to conceive of man as if he were created to be the servant of utilities, trades, professions and careers; these things are for *him*: not ends but means. It is said that intelligence is good because it prospers us in our trades, industries and professions; it ought to be said that these things are good because and in so far as they prosper intelligence. Even if we do not conceive the office of intelligence to be that of contributing to being in its highest form, which consists in understanding, even if we conceive its function less nobly as that of enabling us to adjust ourselves to our environment, the same conclusion holds. For what is our environment? Is it wholly or mainly a matter of sensible circumstance—sea and land and sky, heat and cold, day and night, seasons, food, raiment, and the like? Far from it. It is rather a matter of spiritual circumstances—ideas, sentiments, doctrines, sciences, institutions, and arts. It is in respect of this ever-changing and ever-developing world of spiritual things, it is in respect of this invisible and intangible environment of life, that universities, whilst aiming to give mastery in this part or that, are at the same time under equal obligation to give to such as can receive it some general orientation in the whole.

And now as to the question of feasibility. Can the thing be done? So far as mathematics is concerned I am confident that

it can, and I have a strong lay suspicion that it can be done in all other subjects.

It is my main purpose to show, with some regard to concreteness and detail, that the thing is feasible in mathematics. Before doing so, however, I desire to view the matter a little further in its general aspect and in particular to deal with some of the considerations that tend to deter many scientific specialists from entering upon the enterprise.

One of the considerations, and one, too, that is often but little understood, and so leads to wrong imputations of motive, though it is in a sense distinctly creditable to those who are influenced by it, is the consideration that relates to intricacy and technicality of subject-matter and doctrine. Every specialist knows that the principal developments in his branch of science are too intricate, too technical and too remote from the threshold of the matter to be accessible to laymen, whatever their abilities and attainments in foreign fields. Not only does he know that there is thus but relatively little of his science which laymen can understand but he knows also that the portions which they can not understand are in general precisely those of greatest interest and beauty. And knowing this, he feels, sometimes very strongly, that were he to endeavor by means of a lecture course to give laymen a general acquaintance with his subject, he could not fail to incur the guilt of giving them, not merely an inadequate impression, but an essentially false impression, of the nature, significance and dignity of a great field of knowledge. His hesitance therefore, is not due, as it is sometimes thought to be, to indifference or to selfishness. Rather is it due to a sense of loyalty to truth, to a sense of veracity, to an unwillingness to mislead or deceive. Of course strange things do sometimes happen, and it is barely conceivable that once in a long time nature may, in a sportive mood, produce a kind of specialist whose subject affects him much as the possession of an apple or a piece of candy affects the boy who goes round the corner in order to have it all himself. But if the type exist, not many men could claim the odd distinction of belonging to it. Specialists are as generous and humane as other men. Their subjects affect them as that same boy is affected when, if he chance to come suddenly upon some strange kind of flower or bird, he at once summons his sister or brother or father or mother or other friend to share in his surprise and joy. There is this difference, however—the specialist must, unfortunately, suffer *his* joy in solitude unless and until he finds a comrade in kind. I admit that the deterrent consideration in question is thoroughly intelligible. I contend that the motive it involves presents an attractive aspect. But I can not think it of sufficient weight to be decisive. It involves, I believe, an erroneous estimate of values, a fallacious view of the ways of truth to men. A few years ago, when making a railway journey through one of the most imposing parts of the Rocky Mountains, I was tempted like many another passenger to procure some photographs of the scenery in order to convey to far-away friends some notion of the wonders of it. So far, however, did the actual scenery surpass the pictures of it, excellent as these were, that I decided not to buy them, feeling it were better to convey no impression at all than to give one so inferior to my own. No doubt the decision might be defended on the ground of its motive. Did it not originate in a certain laudable sense of obligation to truth? Nevertheless, as I am now convinced, the decision was silly. For in accordance with the same principle it is plain that I ought to have wished to have my own impressions

erased, seeing that they must have been quite as inferior to those of a widely experienced mountaineer as those which the pictures could have given were inferior to mine. Who is so foolish as to argue that no one should learn anything about, say London, unless he means to master all its plans, its architecture and its history in their every phase, feature and detail? Who would contend that, because we are permitted to know only so little of what is happening in the European war, we ought to remain in total ignorance of it? Who would say that no one may with propriety seek to learn something about ancient Rome unless he is bent on becoming a Gibbon or a Mommsen? It is undoubtedly true that an endeavor to present a body of doctrine or a science to such as can not receive it fully must result in giving a false impression of the truth. But the notion that such an endeavor is therefore wrong is a notion which, if consistently and thoroughly carried out, would put the human mind entirely out of commission. All impressions, all views, all theories, all doctrines, all sciences are false in the sense of being partial, imperfect, incomplete. "Il n'y a plus des problèmes résolus et d'autres qui ne le sont pas, il y a seulement des problèmes *plus ou moins* résolus," said Henri Poincaré. Every one must see that, but for the helpfulness of views which because incomplete are also in a measure false, even the practical conduct of life, not to say the advancement of science, would be impossible. There is no other choice: either we must subsist upon fragments or perish.

Again, many a specialist shrinks from trying to present his subject to laymen because he looks upon such activity as a species of what is called popularization of science, and he believes that such popularization, even in its best sense, closely resembles vulgarization in its worst. He fancies that there is a sharp line bounding off knowledge that is mere knowledge from knowledge that is scientific. In his view science is for specialists and for specialists only. He declines, on something like moral and esthetic grounds, to engage in what he calls playing to the gallery. It might, of course, be said that there is more than one way of playing to the gallery. It could be said that one way consists in acting the rôle of one who imagines that his intellectual interests are so austere and elevated and his thought so profound that a just sense of the awful dignity of his vocation imposes upon him, when in presence of the vulgar multitude, the solemn law of silence. It would be ungenerous, however, if not unfair, to insist upon the justice of such a possible retort. Rather let it be granted, for it is true, that much so-called popularization of science *is* vicious, relieving the ignorant of their modesty without relieving them of their ignorance, equipping them with the vocabulary of knowledge without its content and so fostering not only a vain and empty conceit, but a certain facility of speech that is seemly, impressive and valuable only when, as is too seldom the case, it is accompanied by solid attainments. To say this, however, is not to lay an indictment against that kind of scientific popularization which was so happily illustrated by the very greatest men of antiquity, which was not disdained even by Galileo in the beginnings of modern science nor by Leonardo da Vinci, and which in our own time has engaged the interest and skill of such men as Clifford and Helmholtz, Haeckel and Huxley, Mach, Ostwald, Enriques and Henri Poincaré. It is not to arraign that variety of popularization which any one may behold in the constant movement of ideas, once reserved exclusively for graduate students, down into undergraduate curricula and which has,

for example, made the doctrine of limits, analytical geometry, projective geometry, and the notions of the derivative and the integral available for presentation to college freshmen or even to high-school pupils. It is not to condemn that kind of popularization which is so natural a process that it actually goes on in a thousand ways all about us without our deliberate cooperation, without our intention or our consent, and has enriched the common sense and common knowledge of our time with countless precious elements from among the scientific and philosophic discoveries made by other generations of men.

Finally it remains to mention the important type of specialist in whom strongly predominates the predilection for research as distinguished from exposition. He knows, as every one knows, that through what is called practical applications of science many a scientific discovery is made to serve innumerable human beings who do not understand it and innumerable others who never can. He may or may not believe in avocational instruction; he may or may not regard intelligence as an ultimate good and an end in itself; he may or may not think that the arts and agencies for the dissemination of knowledge, as distinguished from the discovery and practical applications of truth, are important; he may or may not know that the art and the gifts of the great expositor are as important and as rare as those of the great investigator and less often owe their success to the favor of accident or chance. He may not even have seriously considered these things. He does know his own predilection; and so strong is his inclination towards research that for *him* to engage in exposition, espepecially in popular exposition, in avocational instruction for laymen, would be to sin against the authority of his vocation. This man, if he have intellectual powers fairly corresponding to the seeming authority and urgence of his inner call, belongs to a class whose rights are peculiarly sacred and whose freedom must be guarded in the interest of all mankind. It is not contended that every representative of a given subject is under obligation to expound it for the avocational interest and enlightenment of laymen. The contention is that such exposition is so important a service that any university department should contain at least one man who is at once willing and qualified to render it.

I come now to the keeping of my promise. It is to be shown that the service is practicable in the subject of mathematics and how it is so. Let us get clearly in mind the kind of persons for whom the instruction is to be primarily designed. They are to be students of "maturity and power"; they do not intend to become teachers, much less producers, of mathematics; they are probably specializing in other fields; they do not aim at becoming mathematicians; their interest in mathematics is not vocational, it is avocational; it is the interest of those whose curiosity transcends the limits of any specific profession or any specific form or field of activity; each of them knows that, whatever his own field may be, it is penetrated, overarched, compassed about by an infinitely vaster world of human interests and human achievements; they feel its immense presence, the poignant challenge of it all; as specialists they will win mastery over a little part, but they have heard the call to intelligence and are seeking orientation in the whole; this they know is a thing of mind; they are aware that the essential environment of a scholar's life is a spiritual environment—the invisible and intangible world of ideas, doctrines, institutions, sciences and arts; they know or they suspect that one of the great components of that world is mathematics; and so, not as candidates for a profession or a degree, but in their higher

capacity as men and women, they desire to learn something of this science viewed as a human enterprise, as a body of human achievements; and they are willing to pay the price; they are not seeking entertainment, they are prepared to work—to listen, to read and to think.

And now we must ask: What measure of mathematical training is to be required of them as a preparation? In view of what has just been said it is evident that such training is not to be the whole of their equipment nor even the principal part of it, but it is an indispensable part. And the question is: How much mathematical knowledge and mathematical discipline is to be demanded? I have no desire to minimize my present task. I, therefore, propose that only so much mathematical preparation shall be demanded as can be gained in a year of collegiate study. Most of them will, of course, have had more; but I propose as a hypothesis that the amount named be regarded as an adequate minimum. But it does not include the differential and integral calculus. And is it not preposterous to talk of offering graduate instruction in mathematics to students who have not had a first course in the calculus? I am far from thinking so. A little reflection will suffice to show that in the case of such students as I have described it is very far from preposterous. In my opinion the absurdity would rather lie in demanding the calculus of them. No one is so foolish as to contend that a first course in the calculus is a *sufficient* preparation for undertaking the pursuit of graduate mathematical study. But to suppose it necessary is just as foolish as to suppose it sufficient. There was a time when it *was* necessary, and the belief that it is necessary now owes its persistence and currency to the inertia then acquired. Formerly it was necessary, because formerly all advanced courses, at least all initial courses of the kind, were either prolongations of the calculus, like differential equations, for example, or else courses in which the calculus played an essential instrumental rôle as in rational mechanics, or the usual introductions to function theory or to higher geometry or algebra. But, as every mathematician knows, that time has passed. It is true that courses for which a preliminary training in the calculus is essential still constitute and will continue to constitute the major part of the graduate offer of any department of mathematics. And quite apart from that consideration, it seems wise, in the case of intending graduate students who purpose to specialize in mathematics, to enforce the usual calculus requirement as affording some slight protection against immaturity and the lack of seriousness. But every mathematician knows that it is now practicable to provide a large and diversified body of genuinely graduate mathematical instruction for which the calculus is strictly not prerequisite.

Fortunately it is just the material that is thus available which is in itself best suited for the avocational instruction we are contemplating. As the calculus is not to be presupposed it goes without saying that this subject must find a place in the scheme. For evidently an advanced mathematical course devised and conducted in the interest of general intelligence can not be silent respecting "the most powerful weapon of thought yet devised by the wit of man." Technique is not sought and can not be given. The subject is not to be presented as to undergraduates. For the most part these gain facility with but little comprehension. It is to be presented to mature and capable students who seek, not facility, but understanding. Their desire is to acquire a general conception of the nature of the calculus and of its place in science and

the history of thought—such a conception as will at least enable them as educated men to mention the subject without a feeling of sham or to hear it mentioned without a feeling of shame. A few well-considered lectures should suffice. At all events it would not require many to show the historical background of the calculus, to explain the nascence and nature of the scientific exigencies that gave it birth, to make clear the concepts of derivative and integral as the two central notions of its two great branches, and to present a few simple applications of these notions to intelligible problems of typical significance. Even the idea of a differential equation could be quickly reached, the nature of a solution explained, and simple examples given of physical and geometric interpretations. As to the range and power of the calculus, a sense and insight can be given, in some measure of course by a reference to its literature, but much more effectively by a few problems carefully selected from various fields of science and skillfully explained with a view to showing wherein the methods of the calculus are demanded and how they serve. Is not all this elementary and undergraduate? In point of nomenclature, yes. It is not necessary, however, to let words deceive us. We teach whole numbers to young children, but even Weierstrass was not aware of the logico-mathematical deeps that underlie cardinal arithmetic.

The calculus, however, is hardly the topic with which the course would naturally begin. A principal aim of the course should be to show what mathematics, in its inner nature, is—to lay bare its distinctive character. Its distinctive character, its structural nature, is that of a "hypothetico-deductive" system. Probably, therefore, it would be well to begin with an exposition of the nature and function of postulate systems and of the great rôle such systems have always played in the science, especially in the illustrious period of Greek mathematics and even more consciously and elaborately in our own time. It is plain that such an exposition can be made to yield fundamental insight into many matters of interest and importance not only in mathematics, but in logic, in psychology, in philosophy, and in the methodology of natural science and general thought. The material is almost superabundant, so numerous are the postulate systems that have been devised as foundations for many different branches of geometry, algebra, analysis, *Mengenlehre* and logic. A general survey of these, were it desirable to pass them all in review, would not be sufficient. It will be necessary to select a few systems of typical importance for minute examination with reference to such capital points as convenience, simplicity, adequacy, independence, compatibility and categoricalness. The necessity and presence of undefined terms in any and all systems will afford a suitable opportunity to deal with the highly important, much neglected and little understood subject of definition, its nature, varieties and function, in light of the recent literature, especially the suggestive handling of the matter by Enriques in his "Problems of Science." A given system once thus examined, the easy deduction of a few theorems will suffice to show the possibility and the process of erecting upon it a perfectly determinate and often imposing superstructure. And so will arise clearly the just conception of a mathematical doctrine as a body of thought composed of a few undefined together with many defined ideas and a few primitive or postulated propositions with many demonstrated ones, all concatenated and welded into a form independent of will and temporal vicissitudes. Revelation of the charm of the science will have been begun. A

new revelation will result when next the possibility is shown of so interchanging undefined with defined ideas and póstulates with demonstrated propositions that, despite such interchange of basal with superstructural elements, the doctrine as an autonomous whole will remain absolutely unchanged. But this is not all nor nearly all. It is only the beginning of what may be made a veritable apocalypse. Of great interest to any intellectual man or woman, of very great interest to students of logic, psychology, or philosophy, should be the light which it will be possible in this connection to throw upon the economic rôle of logic and upon the constitution of mind or the world of thought. I refer especially to the recently discovered fact that in interpreting a system of postulates we are not restricted to a single possibility, but that, on the contrary, such a system admits in general of a literally endless variety of interpretations; which means, for such is the make-up of our *Gedankenwelt*, that an infinitude of doctrines, widely different in respect of their psychological character and interest, have nevertheless a common form, being isomorphic, as we say, logically one, though spiritually many, reposing on a single base. And how foolish the instructor would be not to avail himself of the opportunity of showing, too, in the same connection, how various mathematical doctrines that differ not only psychologically, but logically also, are yet such that, by virtue of a partial agreement in their bases, they intersect one another, owning part of their content jointly, whilst being, in respect of the rest, mutually exclusive and incompatible. If, for example, it be some Euclidean system that he has been expounding, he will be able readily to show upon how seemingly slight changes of base there arise now this or that variety of non-Euclidean geometry, now a projective or an inversion geometry or some species or form of higher dimensionality. I need not say that analogous phenomena will in like manner present themselves in other mathematical fields. And it is of course obvious that as various doctrines are thus made to pass along in deliberate panorama it will be feasible to point out some of their salient and distinctive features, to indicate their historic settings, and to cite the more accessible portions of their respective literatures. Naturally in this connection and in the atmosphere of such a course the question will arise as to why it is that, or wherein, the hypothetico-deductive method fails of universal applicability. So there will be opportunity to teach the great lesson that this method is not rudimentary, but is an ideal, the ideal of intellect and science; to teach that mathematics is but the name of its occasional realization; and that, though the ideal is, relatively speaking, but seldom attained, yet its lure is universal, manifesting itself in the most widely differing domains, in the physical and mechanical assumptions of Newton, in the ethical postulates of Spinoza, in our federal constitution, even in the ten commandments, in every field where men have sought a body of principles to serve them as a basis of doctrine, conduct or achievement. And if it shall thus appear that mathematics is very high-placed as being, in respect of its method and its form, the ideal and the lure of thought in general, the fault must be imputed, not to the instructor, but to the nature of things.

In all this study of the postulational method the impression will be gained that the science of mathematics consists of a large and increasing number of more or less independent, somewhat closely related and often interpenetrating branches, constituting, not a jungle, but rather an immense, diversified, beautifully ordered for-

est; and that impression is just. At the same time another impression will be gained, namely, that the various branches rest, each of them, upon a foundation of its own. This impression will have to be corrected. It will have to be shown that the branch-foundations are not really fundamental in the science but are, literally and genuinely, component parts of the superstructure. It will have to be shown that mathematics as a whole, as a single unitary body of doctrine, rests upon a basis of primitive ideas and primitive propositions that lie far below the so-called branch-foundations and, in supporting the whole, support these as parts. The course will, therefore, turn to the task of acquainting its students with those strictly fundamental researches which we associate with such names as C. S. Peirce, Schroeder, Peano, Frege, Russell, Whitehead and others, and which have resulted in building underneath the traditional science a logico-mathematical sub-structure that is, philosophically, the most important of modern mathematical developments.

It must not be supposed, however, that the instruction must needs be, nor that it should preferably be, confined to questions of postulate and foundation, and I will devote the remainder of the time at my disposal to indicating briefly how, as it seems to me, a large or even a major part of the course may concern itself with matters more traditional and more concrete.

Any one can see that there is an abundance of available material. There is, for example, the history and significance of the great concept of function, a concept which mathematics has but slowly extracted and gradually refined from out the common content and experience of all minds and which on that account can be not only defined precisely and intelligibly to such laymen as are here concerned, but can also be clarified in many of its forms by means of manifold examples drawn from elementary mathematics, from the elements of other sciences, and from the most familiar phenomena of the work-a-day world.

Another available topic is the nature and rôle of the sovereign notion of limit. This, too, as every mathematician knows, admits of countless illustration and application within the radius of mathematical knowledge here presupposed. In this connection the structure and importance of what Sylvester called "the Grand Continuum," which so many scientific and other folk talk about unintelligently, will offer itself for explanation. And if the class fortunately contain students of philosophic mind, they will be edified and a little astonished perhaps when they are led to see that the method and the concept of limits are but mathematicized forms of a process and notion familiar in all domains of spiritual activity and known as idealization. Not improbably some of the students will be sufficiently enterprising to trace the mentioned similitude in some of its manifestations in natural science, in psychology, in philosophy, in jurisprudence, in literature and in art.

I have not mentioned the modern doctrine variously known as *Mengenlehre*, *Mannigfaltigkeitslehre*, the theory of point-sets, assemblages, manifolds or aggregates: a live and growing doctrine in which expert and layman are about equally interested and which, like a subtle and illuminating ether, is more and more pervading mathematics in all its branches. For the avocational instruction of lay students of "maturity and power" how rich a body of material is here, with all its fascinating distinctions of discrete and continuous, finite and infinite, denumerable and non-denumerable, orderless, ordered, and well-ordered, and with its teeming host of near-

lying propositions, so interesting, so illuminating, often so amazing.

Finally, but far from exhausting the list, it remains to mention the great subjects of invariants and groups. Both of them admit of definition perfectly intelligible to disciplined laymen; both admit of endless elementary illustration, of having their mutual relations simply exemplified, of being shown in historic perspective, and of being strikingly connected, especially the notion of invariance, with the dominant enterprise of man: his ceaseless quest for the changeless amid the turmoil and transformation of the cosmic flux.

CASSIUS J. KEYSER
COLUMBIA UNIVERSITY

PRELIMINARY REPORT ON A SHALER MEMORIAL STUDY OF CORAL REEFS

A LIBERAL grant from the Shaler Memorial Fund of Harvard University, supplemented by a generous subsidy from the British Association for the Advancement of Science with an invitation to attend its meeting in Australia last August as a foreign guest, enabled me to spend the greater part of the year 1914 in visiting a number of islands in the Pacific Ocean with the object of testing various theories that have been invented to account for coral reefs. Thirty-five islands, namely, Oahu in Hawaii, eighteen of the Fiji group, New Caledonia of which the entire coast line was traced, the three Loyalty islands, five of the New Hebrides, Rarotonga in the Cook group, and six of the Society islands, as well as a long stretch of the Queensland coast inside of the Great Barrier reef of northeastern Australia, were examined in greater or less detail. A brief statement of my results has been published in the *Proceedings of the National Academy of Sciences* for March, 1915. A full report will appear later, probably in the *Bulletin of the Museum of Comparative Zoology* at Harvard College. The general conclusions reached are here briefly summarized.

Any one of the eight or nine theories of coral reefs will satisfactorily account for the visible features of sea-level reefs themselves, provided the postulated conditions and processes of the invisible past are accepted: hence a study of the visible features of the reefs alone can not lead to any valid conclusion. Some independent witnesses must be interrogated, in the hope of detecting the true theory. The only witnesses, apart from sections obtained by deep and expensive borings, available for sea-level reefs are the central islands within oceanic barrier reefs, or the mainland coast within a continental barrier reef. The testimony of these witnesses has been too largely neglected, apparently because most investigators of coral reefs have been zoologists, little trained in the physiography of shore lines. Elevated reefs afford additional testimony in their structure and in the relation of their mass to its foundation; but these witnesses also have been insufficiently considered, perhaps because most investigators of reefs have, as zoologists, been little trained in structural geology; hence it seemed desirable to give as much time as possible on the Pacific islands to questioning the independent witnesses above designated, rather than to the study of the reef themselves.

The testimony of the first group of witnesses —the central islands of barrier reefs—convinced me that Darwin's theory of subsidence is the only theory competent to explain not only the development of barrier reefs from fringing reefs, but also the shore-line features of the central (volcanic) islands within such reefs; for the embayment of the central islands testify emphatically to subsidence, as Dana long ago pointed out: thus my results in the study of this old problem of the Pacific agree with those of several other recent students, especially Andrews, Hedley and Taylor of Australia, and Marshall of New Zealand. Darwin's theory of subsidence also gives by far the most probable explanation of atolls; for it is unreasonable to suppose that a subsidence of the ocean bottom should occur only in regions where the central islands of barrier reefs are present to attest it, and not in neighboring regions where reefs of identical appearance,

but without a central island, are given another name.

The testimony of the second group of witnesses—massive elevated reefs such as occur on certain Fiji Islands—convinced me that Darwin's theory of subsidence gives the only satisfactory explanation of the origin of such reefs also; for their limestones rest unconformably on the normally eroded surface of a preexistent foundation. The erosion of the foundation surface shows that it stood above sea-level before the reef was deposited upon it; and the occurrence of the reef shows that the eroded foundation subsided to receive its marine cover. Only after this subsidence was the compound mass uplifted. The mere occurrence of elevated reefs above sea level does not for a moment prove that they were formed during the emergence of their foundation.

All the still-stand theories of barrier reefs—that is, all the theories which involve a fixed relation of the reef foundation to the sea level during the formation of the reef mass—are excluded by evidence of submergence found in the embayed shore lines of the central islands within barrier reefs. It may seem overbold thus at a stroke to set aside several well-known theories, accepted by experienced observers; and so indeed it would be if these observers had discussed the features of the embayed central islands and had explicitly shown that their embayments are not due to submergence, but to some other cause. It is, however, a regrettable fact that the observers who adopted one or another of the still-stand theories took, like Darwin himself, practically no account of the embayed central islands, essential as the testimony of these islands is in the solution of the coral-reef problem. Such neglect is all the more remarkable in view of the clear statement, long ago published by Dana, regarding the pertinence and the value of the testimony afforded by the central islands of barrier reefs.

The glacial-control theory of coral reefs, recently elaborated by Daly with special reference to the lagoons of atolls, will not hold for barrier reefs. This theory assumes that no subsidence of the reef foundations took place, and explains the lagoon floors of atolls as platforms abraded across preglacial sea-level reef-masses by the lowered and chilled sea of the glacial period after the corals were killed; the preglacial reef-masses having been formed by upward or outward growth on their still-standing foundations. It then explains the encircling reefs which now surround the lagoons as having been built up while the sea was rising and warming in postglacial time. But if the broad lagoons of large atolls, 20 or 30 miles in diameter, were thus formed, the central islands within narrow-lagoon barrier reefs should be cliffed all around their shore line, and they are not. Furthermore, this theory explains the embayments of central islands within barrier reefs as occupying new-cut valleys that were eroded during the glacial period of lowered sea level; but if this were the case, the new-cut valleys should be prolonged upstream from the embayment heads as incisions in the floors of preglacial valleys, thus producing a "valley-in-valley" landscape; and this is not true in any one of the hundreds of embayments seen during the past year. Furthermore, many of the embayments are so wide that, if they were opened by slow subaerial processes, all the spur ends ought to have been well cliffed by the sea; yet, as above stated, they are not cliffed. Finally many of the embayments are too wide to have been eroded during the last glacial epoch, or even during all the glacial epochs of the entire glacial period, if the valleys of the formerly glaciated volcanoes of central France are taken as standards of the amount of erosion that could be accomplished in such masses during such intervals of time. The glacial-control theory thus proves incompetent to explain barrier reefs, and it is therefore held to be generally incompetent to explain atolls also; it may have more importance on the borders of the coral zone, where the corals would most likely have been killed during the glacial period: the Marquesas Islands promise interesting results in this connection. The glacial-control theory has its greatest importance in conjunction with Darwin's theory of subsidence, for submergence during subsidence may have been

almost neutralized by the lowering of the sea-level during the oncoming of a glacial epoch, and at such a time coral reefs would broaden and lagoons would become shallow; but with the passing of a glacial epoch the return of ice-sheet water to the ocean would accelerate the submergence due to subsidence, and at such a time coral reefs might be more or less completely drowned: thus the discontinuity of certain reefs on so-called "platforms" may be explained.

All the phenomena which testify to the formation of coral reefs on subsiding foundations can be equally well explained by the assumption of a rise of the ocean surface around or over fixed foundations: but a rise of the ocean surface in any coral-reef region demands a rise of the whole ocean surface; and if the coral-reef foundations are to stand still, a rise of the whole ocean surface can be explained only as the diminished result of a greater rise of the ocean floor in some non-coral-reef region. The conditions involved in this alternative for the simple theory of local subsidence are so extravagantly improbable that, as soon as they are explicitly defined, they must be rejected.

No absolute demonstration of the origin of coral reefs, or, for that matter, of any other geological structure, is possible: the most that can be hoped for is a highly probable conclusion. The conclusions announced above in favor of Darwin's theory are believed to have about the same order of probability as that usually accepted as "proof" in geological discussions.

A number of local conclusions may be briefly announced as follows:

The elevated reef along the south coast of Oahu, Hawaii, was formed during or after a sub-recent period of subsidence, for its limestones enter well-defined valleys that must have been eroded when the island stood higher than now, before the reef-limestones were deposited in them.

The Fiji group has suffered various movements of subsidence and elevation by which its many islands were affected in unlike ways. Elevation has taken place at different times in different islands, for some of the elevated reefs are elaborately dissected, others are very little dissected, and still others remain at sea-level. The embayments due to the latest subsidence on the larger islands, Viti Levu and Vanua Levu, are now largely filled with delta plains. All the reefs, those now elevated as well as those at sea-level, appear to have been formed during periods of subsidence, the evidence afforded by the elevated reefs of Vanua Mbalavu, Mango and Thithia, being especially significant on this point. The medium-sized island of Taviuni has few visible reefs, because its flanks and shores are flooded by sheets of recent lava. The small island of Wakaya seems to be a tilted block of lava beds, not a dissected volcano.

The extensive barrier reef of New Caledonia has grown up during a recent subsidence by which that long and maturely dissected island has been much reduced in size and elaborately embayed; but unlike most encircled islands this one was strongly cliffed around its southeastern end and along much of its northeastern side before the recent subsidence took place.

The two southeastern members of the Loyalty group, Maré and Lifu, are former atolls, evenly unlifted about 300 feet: Maré shows a small hill of volcanic rock in the center of its limestone plateau or elevated lagoon floor. Uvea, the northwestern of the three Loyalty Islands, is a slightly tilted atoll; its eastern side shows an uplifted reef in crescentic form, 100 or more feet high at the middle of its crescent, and slowly descending to sea-level at its horns; the tilted lagoon floor slowly deepens westward and is enclosed by disconnected, upbuilt reef-islands.

The New Hebrides show signs of uplift in their elevated reefs, and of depression in their embayments. There is some evidence that certain uplifted fringing reefs on the island of Efaté, near the center of the group, were formed during pauses in a subsidence that preceded their uplift, and not during pauses in their uplift as inferred by Mawson. The narrowness of the lagoons enclosed by the barrier reefs that encircle certain strongly embayed islands in this group may be explained by supposing alternations of slow and rapid subsi-

dence, so that the earlier-formed reefs, which began to grow when the subsidence was slowly initiated, were drowned when it was later accelerated; and new reefs, thereupon begun on the shore line of that time would after a second period of slow subsidence stand near the present shore line, though the shore line is strongly embayed because the total subsidence has been large. The absence of reefs around the island of Ambrym is due to its abundant eruptions in recent time, the latest one being in December, 1913; scattered corals were seen growing on one of its sea-cliffed lava-streams, thus illustrating the initial stage of a fringing reef.

The Great Barrier reef of Australia, the largest reef in the world, with a length of some 1,200 miles and a lagoon from 15 to 70 or more miles wide, has grown upward during the recent subsidence by which the Queensland coast has, after a long period of still-stand, been elaborately embayed, as was pointed out by Andrews in 1902. A very recent uplift of ten feet has occurred, as was long ago noted by Jukes. There is reason for believing that a broadened reef-plain, with extensive land-fed deltas along the continental margin, had been formed before the recent subsidence took place; and it is this broadened reef, now submerged, that is thought to form the "platform" on which the Great Barrier reef has grown up. Guppy's suggestion that the platform or "submarine ledge" is due to marine abrasion before coral reefs were established here and that no subsidence has taken place can not be accepted. It is highly probable that the well-attested recent subsidence was due to a gentle flexure, by which the off-shore sea-bottom was bent down; and if so, the coastal submergence will give much too small a measure of the thickness of the distant barrier reef. In this respect the Great Barrier reef along the shore of a continent differs significantly from smaller barrier reefs around oceanic islands, in which the subsidence of the island and its reef are essentially uniform.

A few hours on shore at Raretonga, the southernmost member of the Cook group, sufficed to show that extensive embayments formerly entering its elaborately carved mass are now occupied by delta plains and perhaps in part by slightly elevated reef- and lagoon-limestone.

Five islands of the Society group exhibit signs of recent subsidence in their intricately embayed shore lines, as has lately been announced by Marshall. A sixth, the cliff-rimmed island of Tahiti, the largest and youngest of the group, has suffered moderate subsidence after its cliffs were cut, but the resulting bays are now nearly all filled with delta plains which often advance into the narrow lagoon; hence a pause or still-stand has followed the latest subsidence. All the barrier reefs of this group appear to have been formed during the recent subsidence that embayed their central islands.

W. M. Davis

Harvard University

SCIENTIFIC NOTES AND NEWS

Dr. Richard P. Strong, professor of tropical diseases at the Harvard Medical School, has been appointed leader of the American Red Cross Sanitary Commission, which will assemble in Salonica about the middle of next month and proceed to the districts of Servia and Austro-Hungary which are stricken with epidemics of typhus, cholera and other contagious diseases. The commission will be supported by the Red Cross and the Rockefeller Foundation. Dr. Strong has already sailed for Greece, and the rest of the expedition will sail by the end of this month. It includes Dr. Thomas W. Jackson, of Philadelphia; Dr. Hans Zinsser, professor of bacteriology, Columbia University; Dr. Andrew W. Sellards, Dr. George C. Shattuck and Dr. Francis B. Grinnell, of the Harvard Medical School. Dr. Nicolle, the French expert on typhus, has been invited to cooperate with the commission. Mr. Charles S. Eby, of Washington, lately connected with the United States Immigration service, is disbursing officer and secretary for the commission.

The Rockefeller Foundation has made comprehensive plans for improving medical and hospital conditions in China. These are based

on the report of the special commission sent by the foundation to China. To carry out this work the foundation has established a special organization to be called the China Medical Board of the Rockefeller Foundation, constituted as follows: John D. Rockefeller, Jr., chairman; Wallace Buttrick, director; Harry Pratt Judson, Frank J. Goodnow, Dr. Simon Flexner, Jerome D. Greene, John R. Mott, Dr. William H. Welch, Wickliffe Rose, Starr J. Murphy, Dr. Francis W. Peabody and Frederick T. Gates. E. C. Sage is secretary of the board, and Roger S. Greene is to be the resident director in Pekin. The plan outlined by the commission looks to the development of medical education in China as the first step. With a view to building up a body of Chinese medical men able to teach medical science, the foundation has decided to establish six fellowships, each of $1,000 gold a year and traveling expenses, to enable Chinese graduates to study abroad. Six fellows have been appointed, one of whom is already in this country.

THE fifth annual award of the Willard Gibbs Medal, founded by William A. Converse, of Chicago, has been made to Arthur A. Noyes, director of the research laboratory of physical chemistry, Massachusetts Institute of Technology. Dr. Noyes in receiving the medal will address the Chicago Section of the American Chemical Society upon the evening of April 16, his medal address being "A System of Qualitative Analysis including nearly all the Metallic Elements." The recipient of this medal is determined by a jury of twelve, six of whom only can be members of the Chicago section, those outside the section being Alexander Smith, W. A. Noyes, W. H. Walker, T. W. Richards, Leo Baekeland and W. F. Hillebrand. Previous awards of this medal have been to Arrhenius, T. W. Richards, Baekeland and Remsen.

PROFESSOR ROBERT HALLOWELL RICHARDS was given a complimentary dinner on March 18 by the Mining and Metallurgical Society of America, the feature of which was the presentation of the gold medal of the society by the president, William R. Ingalls, former student under Professor Richards at the Massachusetts Institute of Technology. The banquet was in the Chemists' Club, New York, with a distinguished gathering of representative metallurgists from various parts of the country. The speakers besides Mr. Ingalls and Professor Richards were: W. L. Saunders, president of the American Institute of Mining Engineers; Charles W. Goodale, general manager of the Boston and Montana Department of the Anaconda Copper Mine; F. A. Lidbury, president of the American Electro-Chemical Society, and David H. Browne, metallurgical expert of the International Nickel Company.

DR. J. WILLIAM WHITE, professor emeritus of surgery and one of the trustees of the University of Pennsylvania, expects to enter the American Ambulance Service in Paris during the coming summer, taking with him a number of surgeons, physicians and nurses from the University of Pennsylvania staff.

THE following have been selected by the council of the Royal Society to be recommended for election into the society: Professor Frederick William Andrewes, Professor Arthur William Conway, Mr. Leonard Doncaster, Mr. John Evershed, Dr. Walter Morley Fletcher, Professor Arthur George Green, Mr. Henry Hubert Hayden, Dr. James Mackenzie, Professor John Cunningham McLennan, Dr. Arthur Thomas Masterman, Professor Gilbert Thomas Morgan, Dr. Charles Samuel Myers, Mr. George Clarke Simpson, Mr. Alan A. Campbell Swinton, and Mr. Arthur George Tansley.

To Surgeon-General William C. Gorgas has been awarded the Louis Livingston Seaman medal for progress and achievement in the promotion of hygiene and the mitigation of occupational disease.

AT the thirty-third annual dinner of the faculty of medicine of McGill University held in Montreal on February 13, Dr. Lewellys Franklin Barker, of the Johns Hopkins University, was the guest of honor.

PROFESSOR GEORGE PEGRAM, of the department of physics of Columbia University, has been elected president of the Columbia chapter of the Sigma Xi.

Dr. Charles H. T. Townsend has been elected the first honorary member in the New York chapter of the Alpha Mu Pi Omega Medical Fraternity.

Professor A. Looss, formerly connected with the school of medicine, Cairo, Egypt, has retired from that position. His present address is Stephanstrasse 18, Leipzig, Germany.

Dr. J. C. Bose, who has been lecturing in the United States on physiological botany, sailed from San Francisco for the Orient on March 20.

Dr. W. J. Hussey, professor of astronomy at the University of Michigan and director of the observatory, has returned to Ann Arbor, after having spent the past six months at La Plata University in South America.

News has been received from the University of Pennsylvania's Amazon expedition through its director, Dr. W. C. Farrabee. It is the first news that has come through in four months. Dr. Farrabee reports that he has spent three months at work in the interior, where he has been successful in getting much information and many specimens. He further states that he has just started for the highlands on the borders of Bolivia, Peru and Brazil, from which he had to turn back last August.

Professor William Trelease, of the department of botany of the University of Illinois, has been granted leave of absence from the university until May 1, for a botanical expedition to Guatemala, Central America.

Dr. Julius Stieglitz, professor of chemistry and director of analytical chemistry in the University of Chicago, has accepted an invitation to give courses in chemistry at the University of California during the summer term that begins June 21 and closes on August 1. Professor Stieglitz will give a seminar on special topics in organic chemistry and also a college course in organic chemistry.

On March 3, Professor E. E. Barnard, director of the Yerkes Observatory, lectured before the California chapter of the Sigma Xi upon the subject: "Some of the Visible Results of Astronomical Photography." The lecture was illustrated by a remarkable series of astronomical photographs.

Dr. Leland O. Howard delivered a lecture on "Insects and Disease" before the biological club and students of the medical department of Georgetown University, Washington, D. C., on March 11.

Dr. L. A. Bauer gave an illustrated lecture, on March 15, at Smith College, Northampton, under the auspices of the Physics Club, entitled "Following the Compass."

Professor Dayton C. Miller, of the Case School of Applied Science, lectured, on March 4 and 5, at the State University of Iowa. His subjects were (1) "The Science of Musical Sounds" and (2) "The Physical Characteristics of Vowels." Professor Miller also addressed the seminar of the department of physics on some of the more technical parts of his investigations. Professor C. G. Derick, of the University of Illinois, delivered two lectures at the university on March 13. The first was on the subject "The Teacher in Research." The second was upon the study of valence through ionization and dealt largely with Professor Derick's own work.

Dr. Otis W. Caldwell, professor in the University of Chicago, recently spent several days at the Kansas State Agricultural College, where he delivered several lectures to the students and scientific organizations of the college.

Dr. Frederick Winslow Taylor, of Philadelphia, past president of the Society of Mechanical Engineers, known for his inauguration of methods of "scientific management," died on March 21 at the age of sixty-nine years.

It is announced that Dr. Philip Beck, head of the Austrian Army Medical staff, recently died of typhus fever.

Dr. F. A. Bather, of the British Museum, writing in the *Museum Journal* of February, 1915, states that some international scientific activities continue between the countries now at war. Thus the German collaborators of the International Catalogue of Scientific Literature continue to send their manuscript to the

central office in London, while the members of the International Commission on Zoological Nomenclature still record their votes without distinction of country. The British government also permits a limited import of scientific books from Germany and Austria.

A CABLEGRAM to the daily papers was quoted in the issue of SCIENCE of December 25, to the effect that the trained horses of Elberfeld had been requisitioned for an artillery battery and that they had been killed on the battlefield in Flanders. Fortunately this report has proved to be untrue. According to the *Frankfurter Zeitung* of January 22, Herr Krall, the owner of the horses, has written to that paper to the effect that they are safe and well in the hands of a competent horseman, although the experiments upon them are in abeyance during the war.

SIR CHARLES A. PARSONS, the distinguished engineer, has given £5,000 to the Royal Institution, London, for the general purposes of the institution.

THE thirty-seventh annual meeting of the American Library Association will be held at Berkeley, Calif., on June 30.

THE eighth annual meeting of the American School Hygiene Association will take place in the city of San Francisco, June 25–26, 1915. Arrangements for this meeting are being made through the organization committee of which Professor Lewis M. Terman, Stanford University, Stanford, Calif., is chairman. Professor Terman is also chairman of the program committee. The influence of the American School Hygiene Association was very largely responsible for the great success of the Fourth International Congress on School Hygiene which was held in the city of Buffalo in the summer of 1913. It is hoped that the general interest stimulated by this International Congress may be productive of a large and an effective meeting in San Francisco.

UNIVERSITY AND EDUCATIONAL NEWS

WE have received the following telegram signed by five professors of the University of Utah:

"Fourteen members of the University of Utah faculty have resigned—Cummings, dean of art and science; Holman, dean of law school; six department heads—Roylance, history; Ebaugh, chemistry; Vorhies, biology; Mattill, physiology and physiological chemistry; Peterson, psychology, and six others—Butler and Blood, English; Sharp, histology; Hedger, registrar; Stephens, law; Thiel, German. Of the eleven members of the American Association for the Advancement of Science in the University of Utah, but three remain. The immediate cause is the recent dismissal of Knowlton, in physics, Wise, in German, and Bing and Snow, in English, and the demotion of Professor Marshall, for twenty-three years head of the English department and Reynolds, professor of English. For specious and fluctuating reason, without heed to petition from students, faculty, alumni and others, the president refuses an investigation and has been upheld by the board of regents. This is the culmination of a policy of repression that has been growing steadily in the past two or three years, resulting in an entire lack of mutual confidence. We believe this should be known at once for the safeguarding of our successors in the profession. They should come only with their eyes open."

THE dedication of the new Julius Rosenwald Hall in connection with the ninety-fourth convocation of the University of Chicago was held on the morning of March 16. The program included addresses by President Harry Pratt Judson, Professor Rollin D. Salisbury, head of the department of geography and dean of the Ogden Graduate School of Science; Professor Thomas Chrowder Chamberlin, head of the department of geology, and seven alumni of the university who took their degrees in the departments which will use the new building: Eliot Blackwelder, A.B., '01, Ph.D., '14, professor of geology, the University of Wisconsin; Frank Walbridge De Wolf, S.B., '03, director of the State Geological Survey of Illinois; William Harvey Emmons, Ph.D., 1904, professor of mineralogy and geology, the University of Minnesota, director of

the Geological Survey of Minnesota; Wallace Walter Atwood, S.B., '97, Ph.D., 1903, professor of physiography, Harvard University; Edwin Bayer Branson, Ph.D., 1905, professor of geology, the University of Missouri; Ermine Cowles Case, Ph.D., 1896, professor of historical geology and paleontology, the University of Michigan; George Frederick Kay, Ph.D., '14, professor of economic geology and petrology of the State University of Iowa, director of the Geological Survey of Iowa. The exercises were held in the lecture room of the new hall, and the entire building, with its equipment, was then placed on exhibition.

A new site for the Fuertes Observatory of Cornell University has been approved by the committee on buildings and grounds, on the recommendation of a subcommittee which had considered the matter in consultation with Dean Haskell of the College of Civil Engineering. The observatory was torn down last fall to make room for the new drill hall. It is to be erected on the summit of a knoll just north of Beebe Lake, near the east end of the lake. The site is on a part of the Kline farm which was purchased by the university a year or two ago. It is just 900 feet above sea level.

At a meeting of the Yale corporation on March 15, Dr. John Zeleny, professor of physics at the University of Minnesota, was appointed professor in the Sheffield School to succeed Professor Charles S. Hastings. Dr. J. M. Slemons, professor of obstetrics and gynecology in the University of California, was appointed to the corresponding chair in the medical school. Dr. Hiram Bingham was promoted to be professor of Latin-American history; Dr. T. S. Taylor, now instructor, was made assistant professor of physics in the college; Dr. A. F. Holding, of the Cornell Medical School, was made assistant professor of radiography in the medical school; Dr. A. M. Bateman, of Queen's College, was made instructor in biology, and Mr. H. L. Bruce, of the University of California, instructor in engineering.

Dr. Herbert M. Evans, associate professor of anatomy in the Johns Hopkins University and research associate in the department of embryology of the Carnegie Institution of Washington, has accepted a call to the professorship in anatomy and directorship of the department of anatomy of the University of California. Dr. Evans will assume his new duties on July first.

Dr. W. V. Bingham, assistant professor of psychology and education at Dartmouth College and for the past three years director of the summer session, has accepted appointment as professor of psychology in the Carnegie Institute of Technology at Pittsburgh. Dr. Bingham will not leave Hanover until September, after the summer session.

Among new promotions at the University of Chicago are the following: To a professorship: Henry Chandler Cowles, of the department of botany, Charles Joseph Chamberlain, of the department of botany; Otis William Caldwell, of the college of education (botany). To an assistant professorship: J. Harlen Bretz, of the department of geology; George William Bartelmez, of the department of anatomy; Elbert Clark, of the department of anatomy. To an instructorship: Harold S. Adams, of the department of physiology.

Dr. Charles Kenneth Tinkler has been appointed to the readership in chemistry tenable in the home science department of King's College for Women, London. He has been a research student of the University of Edinburgh, and since 1904 lecturer and demonstrator in chemistry in the University of Birmingham.

DISCUSSION AND CORRESPONDENCE

CONRAD RÖNTGEN

The twenty-seventh of March marks the seventieth birthday of Conrad Röntgen, an event which was to have been jointly commemorated by physicists of all nationalities, especially English, French and German, the three which have contributed most markedly to the development of the new era in physics—an era which may with some reason be dated from the announcement in January, 1896, of the discovery of X-rays.

But when last summer the spirit of this new world which has been created by modern science, the spirit of reason, of cooperation, or internationalism, was submerged in the wave of blind nationalism which swept the world back a thousand years towards barbarism, when the crowning glory of science, the objective, impartial search for truth was forgotten, and prejudice and hate alone dictated the words and acts of men, then it was felt necessary to abandon the plans for the Röntgen celebration.

But here in America where, let us hope, the spirit and the method of science still find some advocates, it is fitting that on the twenty-seventh of March we bring honor and appreciation to the seventy-year-old author of one of the world's greatest discoveries—Conrad Röntgen.

R. A. MILLIKAN

UNIVERSITY OF CHICAGO,
March 18, 1915

THE CONTENTS OF A SHARK'S STOMACH

TO THE EDITOR OF SCIENCE: I have received from Mr. W. F. Cameron, of Zamboanga, P. I., a Stanford engineer, a photograph of a rare shark, *Rhinodon typicus,* a specimen about twenty feet long, taken on the island of Cebu. A notable feature about this shark, which has a very big mouth and small teeth, is that it had in its stomach 7 leggings, 47 buttons, 3 leather belts and 9 shoes. He had probably captured the cast-off garments of some company, otherwise the question arises—What became of the odd legging and the odd shoe?

DAVID STARR JORDAN
LELAND STANFORD JUNIOR UNIVERSITY

THE SCALED AMPHIBIA OF THE COAL MEASURES

THE preservation of scales among true Amphibia has been well known for many years, and their presence has been commented on by Huxley, Cope, Dawson and others. Recently the question of the crossopterygian ancestry of the Amphibia has received considerable support through the researches of Gregory, Watson, Broom and Williston, so that it will be of interest to state here the conditions of the scales among the few species of Amphibia from the Coal Measures which show these structures. Scales are known on several genera of diverse relationship and seem to have been present independent of any common ancestry. These structures, presently to be described, are true scales, and are not to be confused with osseous scutes and ventral scutellæ. These latter structures will be dealt with more fully in another place.

Small scales hexagonal in form have been observed in a branchiosaurian genus, *Micrerpeton,* from North America, though this discovery has not so far been confirmed on additional material, although known to occur in another genus, *Eumicrerpeton.* From the Coal Measures of Ohio come two scaled microsaurian genera, one of which is *Cercariomorphus,* described by Cope, though never figured. The scales in this genus do not show many of the fish characteristics, though they resemble remotely some of the more aberrant forms. The scales are dermal tubercles inserted in the skin, without any definite plan of imbrication, such as is common among the fishes, although the scales have a definite arrangement simulating the fishes. The pattern shows a remote resemblance to some of the early ganoids. They are, moreover, true scales, and as such possibly indicate one more link added to the already full chain of facts which ally the Amphibia and the fishes.

The other genus from Ohio possessing scales is imperfectly known, but was tentatively allied, some years ago, to the genus *Ichthyerpeton,* described many years ago by Huxley from the Coal Measures of Ireland. There is no assurance that the forms are so closely related. They both possess scales of a similar pattern and have an identical form of vertebra. The scales in the only known American species are so badly scattered that nothing can be said of their arrangement. Dawson's work on the scaled Amphibia of the Coal Measures of Nova Scotia is well known. He has figured and described very completely the scales of *Hylonomus.* They bear a great resemblance to the scales of *Cercariomorphus.*

The question now before us is whether the

scales of these few species of Coal Measures Amphibia are sufficiently fish-like to be of service in the derivation of the Amphibia from the fishes. One would think that they might be, and it is the intention of the writer to describe and illustrate these structures fully; clearly distinguishing between scales, osseous scutes and ventral scutellæ. These latter may be scale-like, but are always confined to the myomeres of the abdomen, thorax and throat. That some of the ventral scutellæ have a scale-like arrangement is certain, but this arrangement can be accounted for on other grounds. The writer is confident that the ventral scutellæ have an entirely different origin, ontogenetically and phylogenetically, from true scales.

Roy L. Moodie

University of Illinois,
Department of Anatomy,
Chicago

THE COTTON WORM MOTH IN 1912

An enormous migratory flight of the cotton worm moth, *Alabama argillacea* Hubn., was recently reported by Dr. A. P. Saunders[1] as occurring at Clinton, N. Y., on October 10, 1912, the moths swarming into town about 3 A.M. He states also that two or three days earlier a large invasion of the moths occurred at London, Ontario.

It is therefore of especial interest to note that another huge swarm, probably of the same wave of migration, appeared at Hanover, N. H., two days later than at Clinton, N. Y., viz., the early morning of October 12, 1912. Windows and doors of business houses that had been brightly illuminated during the night were literally covered in the morning with these handsome brown moths.

The facts, so far as they go, seem to warrant the conclusion, or at least the hypothesis, that a great wave of these insects from the cotton growing Gulf States was moving in a northeasterly direction at the rate of about 80–100 miles per night. This would require an average rate of flight of only 8–10 miles per hour. Continuing on the same course at the same rate the wave would have reached Augusta, and perhaps Bangor, Me., on October 14, though it is quite possible that the rather heavy rain that fell in New Hampshire on the night of the 12th and 13th may have delayed the flight or changed the direction of its course. Records from that region will be awaited with much interest. Clinton, N. Y., is roughly 300 miles due east of London, Ont., lat. 43° N. Hanover, N. H., is about 160 miles northeast of Clinton, and 43° 42′ N. The part of the wave front that passed through London, Ont., presumably passed considerably to the north of Clinton, if the moths were guided at all by the prevailing winds of October 9 in that vicinity, and traveled, as would be expected, in a northeasterly direction over the length of Lake Ontario.

In a case of this kind, in which winged creatures wander far from their native habitat, it is natural to suppose that the wind has played a prominent part in the dispersal, as when an occasional murre is driven inland by the storms of winter. So far as I have been able to learn, however, from a somewhat superficial examination of the records of the weather conditions of the time, I have found no evidence of any notable atmospheric disturbance sufficient to account for this apparently large and extensive migration. In Ontario and the northeastern states the moths would seem to have encountered only moderate southwest winds, followed on the 10th–12th by unsettled weather and variable winds of no great velocity.

It is impossible at present to say whether light, which has such a powerful control over the movements of butterflies and, to a more limited extent, of moths, was or was not an important factor in this case, but it is a matter worth considering.

This migratory wave seems to have passed to the north of Massachusetts, if one may judge from the scanty data at hand, though Professor Fernald[2] has reported that earlier in the season (Sept. 21–25, 1912) a few of these moths were taken in that state. He mentions a large invasion in 1911, during the last week in September, and another on October 17, 1914,

[1] Science, January 8, 1915.

[2] Science, November 27, 1914.

around Worcester, Mass., and, about the same time, in Pittsfield.

These sporadic and easily traceable migrations of the cotton worm moth, in the opinion of the writer, afford a rare opportunity, with the cooperation of many observers, for a thorough investigation into the causes of insect dispersal. Such an investigation would be likely to bring to light some important facts, of common interest to students of evolution and of economic entomology.

JOHN H. GEROULD

DARTMOUTH COLLEGE,
HANOVER, N. H.

SCIENTIFIC BOOKS

Sugar Analysis: For Cane-sugar and Beet-sugar Houses, Refineries and Experiment Stations and as a Handbook of Instruction in Schools of Chemical Technology. By FERDINAND G. WIECHMANN, Ph.D. New York, Jno. Wiley & Sons. Third edition. 8vo. Pp. xiii + 307. 7 figs. Cloth, $3.00.

The author "has endeavored to cast his material in a form in which it would prove most readily available in the several branches of the sugar industry," and has reduced repetition to a minimum. "The methods and means used in the analysis of sugar and in the analysis of materials used in sugar production, have first been fully discussed, and then specific analytical control of cane-sugar manufacture, of beet-sugar manufacture, and of refining, has been taken up for detailed consideration."

The first seven chapters are devoted to Properties of Sucrose; Instruments Used in Sugar Laboratories; Polariscopes and Accessories; Sucrose Determination by Optical Analysis; Sucrose Determination by Chemical Analysis; Sucrose Determination by Optical and Chemical Analysis; and, Constituents of Sugar Other Than Sucrose; the eighth chapter to Materials Used in the Sugar Industry, the ninth, tenth and eleventh chapters, respectively, to Analytical Control in Cane-sugar Manufacture; Analytical Control in Beet-sugar Manufacture; and, Analytical Control in Refineries. In the twelfth chapter, a Résumé of the Work of the International Commission for Uniform Methods of Sugar Analysis is given. Twenty well-selected sugar tables and the index to the volume occupy the last 70 pages.

The portions dealing with the properties of sucrose, instruments, polariscope and accessories, sucrose determination by optical methods, by chemical methods, by optical and chemical methods, and the constituents of sugar other than sucrose, are clear in definition without being overburdened with detailed description to be found in references cited. In some instances, however, more detailed directions would add value to the volume when being used for instructional purposes. For example, on page 123, in the direction for the determination of woody fiber, no precaution, such as covering the beaker with washed muslin, etc., is directed to prevent loss of portions of fiber in decanting, other than: "The water . . . is decanted carefully, in order to avoid any loss of the weighed sample."

On pages 71 and 178–179, in giving the method of Clerget, the author states that the use of subacetate of lead as a clarifying agent is not permissible, recommending, on page 71, specially prepared blood-carbon, and on pages 178–179 specially prepared bone-black, "if a decolorant must be used."

Some of the methods given in chapter 8, for the analysis of materials used in the sugar industry, could be substituted by more modern and expedient ones. That given on page 146, for the determination of calcium sulphide, could be substituted by the more expedient evolution method used in the steel and iron industry. On page 151, seventh line from the top, in the method for the determination of total phosphoric acid in phosphate paste, the direction, after making alkaline with ammonia and clearing with nitric acid, is: "Add about 10 grams of ammonium nitrate." This is neither necessary nor advisable, when the method of solution is that recommended at the top of the same page, viz., by nitric and hydrochloric acids. The rest of the method, as outlined on this page, could be substituted by that of the Association of Official Agricultural Chemists as given in Bulletin 107, Bureau of Chemistry. On page 153,

"the latent heat of steam formation" is given as 967, instead of 970.4. On page 154, the method given for the determination of moisture and volatile carbon in coal could be replaced by standard ones. On page 155, the author states that, from the data of the proximate analysis, "the calorific power of the coal can be *approximately* calculated by Lenoble's formula" which he gives. A description and instruction in the use of a standard calorimeter at this point would not be amiss. On page 158, under "Water," the direction is to dry total solids and the residue, before driving off organic and volatile matter, at 130 degrees Centigrade to constant weight, instead of at 103 degrees for one half hour. On page 162, the soap method for hardness is given, but no mention is made of the titration methods.

In the chapters on analytical control in cane-sugar factories, beet-sugar factories and refineries, the author tabulates the work involving control of sugar materials and products, indicating what determinations are necessary on each. He avoids repetition as much as possible by referring to the directions for analytical methods given in the chapters devoted to outlines and discussions. One would call attention to the direction for determination of sucrose in molasses, on page 181. Under Clerget, on this page the following is given: "The direct polarization and the polarization after inversion should be carried out on portions of one and the same solution; for this reason two or three times the normal weight of molasses should be dissolved in 500 c.c. of water. The determination is then carried out as previously directed." Doubtless he intends that the dilution should be to 500 c.c. instead of "dissolved in." Since in giving the method of Clerget on pages 71 and 178–179, it is stated that the use of subacetate of lead is not permissible, but if a decolorant must be used specially prepared blood-carbon or bone-black should be employed, the operator or student would refer to these directions when preparing his solution for the double polarization of molasses, thereby omitting clarification with lead compounds and subsequent deleading but resorting to decolorization with bone-black or blood-carbon, unless he perchance referred to the Meissel-Hertzfeld method as given in chapter 6, page 94, which he is hardly expected to do since this method is given and discussed in the chapter given to the determination of sucrose by optical and chemical methods and not to the determination by optical methods as Clerget calls for. Evidently the author would not recommend clarification of molasses with subacetate of lead when determining sucrose by the Clerget method.

Chapter 12 is an invaluable addition to the volume, as a résumé of the work of the International Commission is here given, which is not always at the hands of the chemist, either in the original transactions or in compilation. It is commendable that this so-important work is compiled and condensed in an available form.

The tables given are well selected and will meet the needs of the sugar analyst, except table 18 (that used in calculating the percentage of commercial sugar recovered from the sucrose in the massecuite as given by I. H. Morse), which is incomplete and would be of little service except in refineries.

The subject-matter of the volume is well correlated, repetitions are few, and the style and appearance of the book are good. Although criticism is here brought of some of the methods of analysis, as given in chapter 8, and attention called to the method for the preparation of the solutions in the determination of sucrose in molasses, and to the incompleteness of table 18, this work will be an addition to any technical library and of aid to the analyst experimenter and student, when working on commercial sugars and allied products and following routine analytical work in sugar houses and refineries.

C. S. Williamson, Jr.
Tulane University of Louisiana

Electric Arc Phenomena. By Ewald Rasch. Translated from the German by K. Tornberg. New York, D. Van Nostrand Company. 1913. Pp. 194.

The introduction contains a discussion of the relative merits of the electromagnetic and

the electrodynamic theory of light in which the author demonstrates the ascendency of Wilhelm Weber over James Clerk Maxwell and predicts that "the explanations furnished by the electronic theory . . . contain the germs of future progress in electric-light engineering." The reasons for this prophecy, however, are not disclosed.

After explaining what an arc is, the conditions under which it is formed and the method of adjustment the author describes the physical and chemical properties of typical electrode materials and the process of manufacture of carbon electrodes. This is followed by a brief discussion of the theory of electrical discharges based upon the electronic theory. In the fifth chapter the author reviews some of the investigations made upon spark discharges between electrodes of different shapes in air. The treatment of this subject seems scant and antiquated in view of the many pertinent investigations made during the past ten years. The effect of gas pressure, humidity, temperature and kind of gas is not considered.

The most valuable contributions to the subject are made in the last three chapters. The sixth chapter has to do with the voltage and current conditions in the direct and alternating-current carbon arc lamp, the seventh with the distribution of energy in carbon arc lamps and vapor tubes, and the eighth with the relation between power and light emitted by plain and mineralized carbon arc lamps and vapor tubes.

The author confesses that some of his remarks are of purely didactic nature, and these digressions, although prohibitive of smooth development of the subject, contain many valuable suggestions. In expressing his disapproval of the term "watts per candle" the author has anticipated the recent suggestion of the term "lumens per watt." In remarking that "physiological effects can no more be expressed in mechanical horse-power than can, for instance, Beethoven's 'Ninth Symphony'" it would seem, in view of the measurements reported by our modern nutrition laboratories, that the author might have chosen a less vulnerable example. The text at times seems to rise above the subject, the discussion in places being supported by cosmogonic reflections and the fourth dimension.

R. G. HUDSON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SPECIAL ARTICLES

LIGHT AND THE RATE OF GROWTH IN PLANTS

A STUDY of the development of about a hundred seed-plants in darkness in an equable temperature chamber from 1900–03 in the New York Botanical Garden gave foundation for the following statement:

> The failure of a large proportion of the forms examined to make an accelerated or exaggerated growth when freed from the influence of light, even when provided with an adequate food-supply, shows that light has no invariable or universal relation to increase in length, or thickness or to the multiplication or increase in volume of separate cells.[1]

Precision appliances for the measurement of illumination and of other environmental conditions in daylight were not available at that time, and it was therefore not possible to follow the contrasting reactions which accompanied illumination and shading of the large plants which were the subjects in the extended experiments. In one series, however, the peduncles and scapes of *Arisaema* nearing the end of their period of elongation showed in initial acceleration when light was totally excluded from the plants. This acceleration reached its maximum in twenty-four hours then decreased to a minimum equivalent to the original rate in about four times this period. The older plump assertion that "light retards growth" continued to be cited without modification by writers of text-books and compendiums. The few investigators who turned attention to the subject have been content with referring to such cyclopedias. Thus Blaauw[2] says, in discussing positive and negative photogrowth reactions:

[1] MacDougal, "Influence of Light and Darkness on Growth and Development," *Mem. N. Y. Bot. Garden*, 2, pp. 307, 308, 1903.

[2] "The Primary Photogrowth Reaction and the Cause of the Positive Phototropism in *Phycomyces nitens*," Kon. Akad. van Wetensch. te Amsterdam. Proc. of meeting, January 31, 1914.

With regard to the existence of a sharply defined reaction of this kind, practically nothing can be deduced from literature references, at least the general opinion about the influence of light on growth is completely at variance with these facts. In the first place so far as concerns the positive or negative influence of light, the general conception, supported by numerous facts, is that light exercises a retarding influence on growth.

Blaauw's results which are described in the paper mentioned above and in a later paper[3] confirm my original thesis that light does not exercise a flat or invariable effect on growth. Furthermore Blaauw's beautifully arranged experiments by which sporangiophores of the mould were exposed to illumination from four or eight sides, with controlled intensities, demonstrate that the first reaction of this organ to a sudden illumination is an accelerated rate of growth, followed by a gradual decrease from which a recovery is made to the original rate. It is to be seen that the general mode of change is similar to that of massive organs deprived of light as described above. American reviewers seem to have been equally ignorant of my earlier experiments, which had the force of rendering the older generalization invalid. Furthermore the indirect effect of light in conditioning differentiations of tissues and thus affecting growth-elongations was pointed out. Blaauw has made an important contribution by his experimental analysis of the action of light on such simple structures as the sporangiophore of a mould.

The elongation or enlargement of a cell or of any structure like that of the sporangiophore of *Phycomyces* may be taken as the expression of inequality between the extensibility of the cell material, and its membrane, and of some internal expanding or stretching force. The osmotic pressure of the contents of the vacuoles, or of solutions filling the protoplasmic interstices has hitherto been relied upon to furnish the necessary force of growth.

Borowikov has recently established a parallel between the growth of certain seedlings in known definite solutions and the hydratation of colloids in the same solutions. This author is therefore led to believe that the stretching force of growth is not osmotic but hydratation pressure, and he relegates osmotic pressure, turgidity and its corollaries to an inconsequential place in the entire matter.[4]

Several features of the growth and hydratation of cacti are not without importance in connection with any consideration of this matter. The researches of Richards and of Spoehr at the Desert Laboratory show that the acidity (malic and oxalic) of the sap of cylindropuntias and platypuntias decreases from its maximum at daybreak to a minimum at about 4 P.M. in the open. The decrease has been shown to be due to the conjoint disintegrating action of temperature and chiefly of light. The calibrations made by Mr. E. H. Long (paper now in press) brought out the fact that if small cylinders were cut from the bodies of these cacti in series beginning at daybreak and extending to the period of minimum acidity, the hydratation capacity of the pieces increases independently of osmotic pressure throughout the day and is greatest in those which have been taken from the plant at the time when collateral tests would indicate the lowest acidity.

Extensive auxanometric records of *Opuntia Blakeana* made chiefly in March and April show that the growth of the enlarging joints is at a minimum in the morning, with a rapid acceleration parallel with the rising temperature of the open, reaching a maximum about noon and then decreasing to a minimum before 3 P.M. The curves of decreasing acidity and increasing hydratation capacity are symmetrical through the range of acidity from N/10 to N/20 according to available data obtained from these plants, and would probably sustain a similar relation in weaker solutions if the acidity were reduced still further.

From the records cited above however it is to be seen that the acceleration of the rate of growth does not follow that of hydratation to its customary daily maximum. Whether this divergence is due to a shrinkage following a heightened water-loss is not yet known. An ample supply was available to the absorbing

[3] "Light und Wachstum," *Zeitschr. f. Botanik.*, Hft. 8, 1914.

[4] Borowikow, "Ueber die Ursachen des Wachstums der Pflanzen," *Biochem. Zeitschrift*, 48: pp. 230–46, 1913.

surfaces within a few cm. of the expanding masses of cells, but local transpiration may have resulted in actual shrinkage. The optimum temperature for this plant is also a feature not yet determined.

The growth of the opuntias therefore takes place during a period of decreasing acidity resulting from the disintegrating action of light and rising temperatures. This statement applies not only to the diurnal behavior of the plants during the growing season, but to the growing season as a whole, which as Dr. H. M. Richards has pointed out in a paper now in press is one of diminishing acidity. The acidities of the cacti are calculated for the sap of the plants. The acidities of N/100 to N/3,000 found by Borowikow to be favorable for hydratation and growth were of the culture solution; that of the sap of the seedling used was probably still much lower.

Light and temperature in lesser degree are seen to exercise a totalized releasing effect on growth coincident with reduced acidity and increased hydratation, to a certain limit. Beyond this growth rate is checked. Further analytical tests will be necessary to determine the limiting factors.

D. T. MACDOUGAL
DESERT BOTANICAL LABORATORY

PROCEEDINGS OF THE ANNUAL MEETING OF THE AMERICAN SOCIETY OF ZOOLOGISTS HELD IN PHILADELPHIA, 1914. II

Multiple Human Births: G. H. PARKER.

Multiple births are well known among human beings and the proportions of twins, triplets, and quadruplets to single births have often been recorded. Instances of five and six children at a birth are very rare but apparently well authenticated. All cases above six are very doubtful. In the *Boston Medical and Surgical Journal*, Volume 10, page 224, 1872, is recorded from Trumbull County, Ohio, a case of eight children at a birth. This very circumstantial account, which has been quoted in numerous books and journals, proves on investigation by the county clerk of Trumbull County to be entirely fictitious.

Comparative and General Physiology

Effect of Electrolytes Upon the Rate of Nerve Conduction in Cassiopea: ALFRED G. MAYER.

Further Studies on the Behavior of Amœba: ASA A. SCHAEFFER.

The Significance of Certain Internal Conditions of the Organism in Organic Evolution: F. H. PIKE AND E. B. SCOTT.

Zoologists, while studying the phenomena of form regulation in animals, have given comparatively little thought to the regulation of internal conditions—the changes in matter and energy in the organisms which underly the changes of form.

The data accumulated in the physiological laboratories show that in the higher animals there is a regulation, varying within relatively narrow limits, of body temperature, the blood pressure, the tension of carbon dioxide and oxygen, of the concentration of hydrogen and hydroxyl ions, of the osmotic pressure, and of the general composition, quantitative as well as qualitative, of the fluids of the body, brought about by a number of systems and organs of the body.

From the point of view of the physical chemist, the general constancy of internal conditions of the higher organism may be interpreted in terms of chemical equilibrium. If the reactions within the body are of the nature of the "slow" reactions of the chemical laboratory, the constant temperature and the constant physico-chemical concentration of the body fluids would be attended by a speed of reaction within the body which would be, in a considerable degree, independent of the conditions in the environment. The internal mechanisms of the organisms lie at the base of the diminishing effect of the environment, or the greater degree of independence of the animal from the conditions of the environment as the organisms occupy successively higher positions in the evolutionary scale.

Experiments on X-Radiation as the Cause of Permeability Changes: A. RICHARDS.

Some Factors Concerned in the Death of Paramœcium at High Temperatures: M. H. JACOBS.

The Effect of Color in the Environment on the Color Changes of Anolis Carolinensis: MANTON COPELAND.

It is well known that the so-called *Florida chameleon, Anolis carolinensis* Cuv., becomes green in the dark and almost invariably turns brown in daylight. To test the effect of color in the environment on the color changes in the skin of the lizard, the animals were placed in boxes lined in part with colored paper and exposed to daylight. It was found that the green color was often assumed under such conditions. A yellow environment always induced a change from brown to

green. Green surroundings were nearly as effective in bringing about this reaction, whereas red and blue were much less so. When placed in a white box certain individuals became green. The brown color was assumed when a box lined with black paper was substituted for a color box. The green hue persisted with slight change for several hours when the animal was in the yellow environment.

When a lizard was blindfolded it remained brown in the yellow box, and numerous tests showed conclusively that the organs concerned in receiving light stimuli, which induced a color change in the skin from brown to green, were the lateral eyes.

The Absorption of Fat by Fresh-water Mussels: E. P. CHURCHILL. (Introduced by Caswell Grave.)

The work was undertaken for the U. S. Bureau of Fisheries with the object of ascertaining whether or not aquatic animals use food which is in solution in the water. Mussels were kept in soap solutions made from olive oil, both unstained and stained with Sudan III. Histological examination of such mussels and of controls revealed the fact that fat is absorbed abundantly and carried over the body by the blood corpuscles and plasma. Sections of mussels kept in fat solutions short periods, as 18 or 24 hours, showed such a heavy loading of fat in the epithelium of gills, mantle and foot that it seemed very probable that the cells of such epithelium absorbed the fat directly from the solution. Mussels with the valves wedged open were suspended over the solution, so that only the ventral part of the foot and mantle were immersed, the mouth and siphons being above the solutions. Examination after some hours of the parts of epithelium so exposed showed more fat than in the epithelium of other parts or in that of the corresponding regions of the control. Fat can be absorbed from solution by the epithelium of intestine and probably outer body walls.

Vision in Flounders: S. O. MAST.

Flounders, especially *Paralichthys* and *Ancylopsetta*, simulate the background to a most remarkable degree. The process of simulation involves changes in shade, in pattern and in color. Since all of these changes are controlled by stimuli received through the eyes, the nature and the degree of simulation of the background constitutes an excellent criterion of vision, in so far as this term may be used in a purely objective sense.

On the basis of this criterion it was found that, in regard to shade and color, vision in fishes is essentially the same as it is in human beings. It was also found that these animals distinguish between dots 2 mm. and 3 mm. in diameter respectively, that they recognize dots 1 mm. in diameter but that they do not recognize dots 0.5 mm. in diameter.

By means of a background consisting of a rotating disk which contained alternate black and white sectors, it was found that the fusion-rate of images in flounders corresponds very closely with that in the human being, indicating that in regard to motion vision in fishes is as acute as it is in man.

On a background containing only gray or black and white, no color is produced in flounders regardless of the shade or pattern or the intensity of the light. Simulation in color is consequently dependent upon the length of the waves of the light, not upon differences in its intensity. It therefore strongly supports the contention that fishes have color-vision. This is, moreover, supported by the fact that flounders adapted to a given color tend to select a background of the same color, and the fact that this selection is of such a nature that it can not be accounted for on the basis of difference in the intensity of the light reflected by the different colors. Thus the contention that fishes have color-vision is supported both by the reactions of the animals and by the reactions of the chromatophores in the skin.

Influence of Thyroid Ingredients on Division-rate in Paramœcium: R. A. BUDINGTON AND HELEN F. HARVEY.

Paramœcia of known ancestry were placed in bacterial infusions of known composition. These were kept on hollow slides in moist chambers in the usual manner. To certain slides were added equal amounts of dried thyroid glands taken from types of each of the five main subdivisions of Vertebrata. Besides each thyroid-treated line was carried a control line, two progeny of a single dividing individual being used in the experiment.

The number of individuals resulting from fission in each line was counted each day; at the end of six days the following were the data secured, each figure being the average of three repetitions of the same experiment:

Fish thyroid	70.6
Control	36.6
Amphibian thyroid	111.3
Control	20.0
Reptilian thyroid	225.3
Control	24.3

Avian thyroid	222.0
Control	43.6
Mammalian thyroid	315.3
Control	57.3

The conclusion is that throughout the evolution of the vertebrate phylum, the thyroid has retained certain of its physiological characters intact. The observations previously made by Nowikoff, later by Shumway, on mammalian thyroid influence on *Paramœcium* are thus confirmed, and the significance of the facts extended so as to include the homologous glands of each of the other four classes of vertebrates.

The Effect of the Removal of the Marginal Sense Organs on the Rate of Regeneration in Cassiopea Xamacana: LEWIS R. CARY.

The results of the investigations of most workers on regeneration has shown that no direct effect of the nervous system upon regeneration could be demonstrated. Zeleny concluded as a result of his work on Cassiopea that when the sense organs were removed the animals regenerate sometimes faster and sometimes slower than do specimens with the sense organs intact. Stockard removed the sense organs from one half of a *Cassiopea* disk and insulated the two halves by removing a strip of sub-umbrella tissue so that one half was active, the other inactive, and found that the rate of regeneration was the same in both halves. From these experiments he concluded that muscular activity had no influence on the rate of regeneration.

In a large series of experiments on *Cassiopea* disks prepared in the manner just mentioned I have obtained the following results:

1. When entire disks are used for the experiments those from which the sense organs have been removed may regenerate slower or faster than those retaining their sense organs on account of individual variation in the rate of regeneration.

2. In specimens prepared so that one half is active, the other inactive, the active side (that bearing the sense organs) always regenerates fastest. The difference in rate is particularly noticeable in earlier stages of regeneration.

3. When the sense organs are removed from one half of the disk, but the halves not insulated, the rate of regeneration is the same for both sides. If only a single sense organ remains the results are the same.

4. In a solution made up of sea water to which has been added 15 volumes per cent. of 0.6 M $MgSO_4$ the regeneration is equal from both sides, but at the rate of the inactive half of a specimen from which one half the sense organs have been removed.

5. In specimens from which all sense organs have been removed but in which one half is kept in pulsation by means of a trapped wave of contraction, the regeneration is the same for both halves, although the rate of contraction in the active half may be higher than for a half disk on which the sense organs are present.

The rate of metabolism as determined for the writer by Dr. S. Tashiro is higher for the half disk bearing sense organs than for the inactive half, or for the half that is kept in contraction by means of a trapped wave.

The Locomotion of Actinians: G. H. PARKER.

The creeping habits of *Metridium* and *Sagartia* were studied at Woods Hole and of *Condalactis* and *Actinia* at Bermuda. *Metridium* and *Sagartia* creep slowly and in directions which may be in one individual at right angles to its axis of structure, in another coincident with it, and in still another oblique to it. Whether one individual could assume in sequence all these directions was not ascertained for these sea anemones. In *Condalactis* and *Actinia* the creeping was more actively carried out than in *Metridium* and *Sagartia*. A single *Actinia* crept now in the direction of its axis, now at right angles to it, and now in some other direction. There is no reason to suppose that this freedom is not possessed by the other sea anemones. In all the forms studied locomotion was accomplished by a wave-like movement of the foot. This began at the rear edge of the foot and proceeded to the front edge. It was exactly like the direct type of wave seen in the mollusk foot, but could be established temporarily on any axis. In *Condylactis* it required about three minutes for a wave to pass over the foot and with each wave the animal progressed a little over a centimeter in distance.

The Behavior of an Enteropneust: W. J. CROZIER.

A species of *Ptychodera* found in Bermuda was studied with reference to its movements and sensory reactions. The orderly progression of peristaltic waves on the thorax and abdomen was found to depend upon the continuity of the dorsal and ventral nerve cords. At night the animal responded to general mechanical stimulation by the emission of a phosphorescent material from the collar region. *Ptychodera* showed "differential sensitivity" to light; it was not photographic.

Local reactions were obtained in response to mechanical and chemical stimulation, the order of decreasing sensitivity of the parts of the animal being: proboscis, posterior end, genital pleuræ, the alkaline metals the normal lyotropic series, abdominal surface, collar. For the chlorides of $K > NH_4 > Li > Na$, was found to express their stimulating efficiency; this was mainly a kation stimulation, but in the case of salts ($CaCl_2$, *e. g.*,) which did not stimulate strongly, other anions (in this case $Ca(NO_3)_2$) were effective as stimulating agents. Photic sensitivity was readily separated, by exhaustion or anæsthetics, from mechanical and chemical; but for the two latter forms of irritability no physiological separation was discoverable. It is therefore suggested that in *Ptychodera* there are generalized receptors open to stimulation by both mechanical and chemical means.

On a Certain Fibrin Reaction Which Occurs in Living Cultures of Frog Tissues: George A. Baitsell.

In living cultures of various tissues of the adult frog there occurs, in many instances, a transformation of the fibrin net of the plasma clot in which the living tissue is embedded. In general the changes which occur first make their appearance when the culture is from two to three days old. During these changes the elements of the fibrin net appear to fuse or consolidate and as a result there are formed a great number of fine wavy fibrils which unite to form bundles of fibers, and these freely intertwine and anastomose as they ramify throughout the area of the plasma clot. The transformation of the fibrin net begins first in the region of the clot which lies in immediate contact with the embedded tissue and gradually extends to the distal regions of the clot until after a time practically the entire plasma clot becomes changed into a tissue greatly resembling that found in various types of connective tissues. Photographs of both living and preserved cultures have been made to show the transformation of the clot and the development of the fibers. Experimental work shows definitely that the fibers arise by a transformation of the fibrin net and are not due to any intracellular action. The work also indicates that the transformation will not take place without the influence of living tissues, although mechanical factors may be introduced which will aid in the formation of the fibers. Various experiments made to determine the true nature of the fibers give conflicting results. The fact, however, that the fibers have also been found to occur in the fibrin net during wound healing indicates that they play an important part in such a process. Studied histologically with a Mallory stain, there appears to be nothing to differentiate them from regular connective tissue fibers. Work is in progress to determine their final fate and the relation they bear to permanent connective tissue fibers.

Studies on the Phosphorescent Substance of the Fire-fly: E. Newton Harvey.

Dried powdered luminous tissue of the fire-fly will phosphoresce strongly if moistened with water containing oxygen. If first extracted with boiling ether or a mixture of equal parts boiling ether and alcohol for eight hours and the solvent then removed, strong phosphorescence still occurs when water containing oxygen is added to the dry powder residue. Similar results are obtained with hot chloroform and acetone, and cold carbon tetrachloride and toluol.

If oxygen-free water is added to the dry powdered luminous tissue no phosphorescence occurs. If oxygen is then added light is emitted. But if no oxygen be admitted until an hour or more after contact of the powder with oxygen-free water, then phosphorescence does *not* occur. Salt, acid and alkaline solutions give similar results.

From these experiments we may conclude: (1) that the photogenic material is not a fat or a lecithin; (2) that the photogen or some accessory substance is unstable and decomposes in the presence of aqueous solvents even though oxygen be absent. The change is therefore not oxidative in nature. It is well known that the photogen oxidizes readily in presence of oxygen and is used up with light production.

Dried luminous bacteria give similar results, with this exception, that extraction with chloroform, acetone and a mixture of equal parts boiling alcohol and ether destroys or weakens the powder to phosphorescence. The bacterial photogen is also unstable if the bacterial cell is broken up in the absence of oxygen.

Some Experiments on Fundulus Eggs Aiming at the Control of Monstrous Development: E. J. Werber.

Starting from the assumption that human and other mammalian monsters found in nature may be due to a pre-uterine or intra-uterine poisoning by the substances found in the blood under pathological conditions of metabolism, such as diabetes, nephritis, jaundice, etc., eggs of *Fundulus hetero-*

clitus were subjected to the action of solutions of urea, butyric acid, lactic acid, sodium glycocholate and ammonium hydroxide. Conclusive results were obtained only with butyric acid and acetone.

The effects of both these substances are very similar. If *Fundulus* eggs are subjected to their influence, they will give rise to a great variety of monsters. Cyclopia, asymmetric monophthalmia and neuroplastic development (microembryones, hemiembryones anteriores) were found to occur most frequently. Not uncommonly is the occurrence of acardia in malformed embryos. In some eggs a heart and rudimentary blood-vessels have developed without the presence of an embryo.

The ear vesicles are very often involved in malformations, their size being enormous, owing apparently to edema. Some locomotor anomalies in embryos, which had hatched, pointed to injury sustained by the semicircular canals.

The rarest in occurrence, but probably the most significant from the standpoint of experimental embryology, were found some cases where all that had developed in the egg was a fragment of brain tissue which had given rise to an eye. This "solitary" eye was found to be almost perfect in some cases, while in others the choroid fissure had failed to close ("coloboma"). Sections of one of these eggs show an eye typical in structure. This would seem to establish the fact of the ability of independent development of the eye.

Reactions to Light in Vanessa lantiopa, with Special Reference to Circus Movements: WM. L. DOLLEY, JR. (Introduced by S. O. Mast.)

The Reactions of the Melanophores of Amblystoma Larvæ: HENRY LAURENS.

A Case of the Change of Fat, in Nature, to Calcium Soap: R. W. H. WOLCOTT.

The Balance Between the Hydrochloric Acid of the Stomach and the Sodium Carbonate of the Pancreas in Its Relation to the Absorption and Utilization of Sugar: J. R. MURLIN.

The Electric Nerve Centers in the Skates: ULRIC DAHLGREN. (With lantern.)

Food Reactions of the Proboscis of Planaria: WM. A. KEPNER AND ARNOLD RICH.

The removal of part of the proboscis sheath results in exploratory movements of the proboscis. As the sheath is further removed these exploratory movements become more pronounced. Such movements, however, are not maintained for more than two minutes.

Sectioning the living animal posterior to the base of the proboscis does not disturb in any other manner the proboscis. By removing anterior parts of the body little disturbance of the proboscis results until the plane of sectioning gets quite near the base of the proboscis, when the latter undergoes either mechanical or autoamputation and leaves the proboscis sheath and for at least ten minutes swims about as an independent organism, ingesting food in a futile manner. The proboscis thus freed frequently turns upon its own body and by ingesting it reduces the body to mere pulp.

It is concluded, therefore, that there is resident in the proboscis an instinct to ingest objects. The inhibitory control of this instinct does not lie in the dorsal ganglia, but in a region of the body anterior to and quite near the base of the proboscis.

Preliminary Report on the Relations Between the Reactions of Rhabdocœles and Their Environments: WM. A. KEPNER AND W. H. TALIAFERRO.

In a previous paper[2] the authors showed that *Microstoma caudatum* when kept under laboratory conditions shows two physiological conditions. In the first place if they are experimented on a few hours after collection they will distinguish between their aquarium water and 5/100 per cent. ordinary salt solution. However, if they are experimented on over a day after collection they do not make this distinction, thus showing that their physiological condition has been lowered. We, likewise, showed that this lowering of physiological condition is due to the rapid accumulation of bacteria under laboratory conditions.

While experimenting on a number of other species of *Rhabdocœles* we found that some showed this loss of physiological condition just as *Microstoma*, while others showed no lowering of their physiological condition, no matter how long they lived under laboratory conditions.

To find an explanation of these results, which at first seemed contradictory, we investigated the natural habitat of the various animals. Here we found that those animals which showed a lowering of physiological condition lived rather deep under the surface of the pond, on roots, where there were relatively few bacteria. On the other hand those that did not show this lowering of condition lived near the surface, in the presence of a great amount of decaying vegetable matter, and hence a great number of bacteria.

[2] "Sensory Epithelium of Pharynx and Ciliated Pits of *Microstoma Caudatum*," *Biol. Bull.*, Vol. XXIII., No. 1, 1912.

From these experiments we conclude that those animals that live in the presence of a great number of bacteria can withstand the action of these bacteria, while those that do not, can not withstand this action, or that the natural habitat of the animal is the real conditioning factor in its reactions.

The Rhythmic Pulsation of the Cloaca of Holothurians: W. J. Crozier.

The cloacal region of pedate holothurians contains within itself the mechanism of its coordinated pulsation. The isolated cloacal end pulsates rhythmically for many hours after its separation from the rest of the animal, and forms a very simple prepared object with which to investigate phenomena of rhythmic movement. The rate of pulsation of the isolated cloacal extremity of *Stichopus mœbii* was found to have a temperature coefficient of about 2.4; it was capable of long continuance in water practically free from dissolved oxygen. The coordinating mechanism was much more powerfully affected by nicotine and atropine than by cocaine or morphine. The duration of pulsation and of irritability to mechanical stimulation in diluted sea water was proportional to about the square of the concentration. The alkaline chlorides preserved pulsation and irritability in the order:

$$NaCl > LiCl > NH_4CK > KCl \cdot MgSO_4$$

was a more powerful depressant than isomolecular or (Mg-) isionic $MgCl_2$. Each one of the salts of sea water was necessary for the continuance of pulsation; this was notably true of $MgSO_4$, which led to normal relaxation after systole. Alteration of the C_H. from $\rho_H = 8.0$ (normal) to $\rho_H = 6.0$ was sufficient to produce stoppage of pulsation within 5 minutes. The brownish skin pigment was given out under abnormal ionic or osmotic conditions, and afforded some index of permeability changes.

Ecology

Altitudinal Distribution of Plankton Crustacea in Colorado: G. S. Dodds.

In 284 collections from 124 lakes and ponds, at elevations between 4,100 and 12,188 feet, the author found 50 species of Entomostraca. Other records raise the list to 69 species (Phyllopoda 14, Cladocera 35, Copepoda 20). There are 22 species confined to the mountains, 27 found only in the plains, and 20 range more or less widely through both areas. More definitely, there may be recognized four zones, marked more or less clearly by physiographic, climatic and faunal characters, as follows: Plains Zone, up to 5,400 feet; Foothill Zone, 5,400 to 8,500 feet; Montane Zone, 8,500 to 11,000 feet; Alpine Zone, above 11,000 feet. In determining distribution of species and boundaries of zones, temperature seems to be the most important factor.

In climate and fauna, these zones have their nearest geographical equivalents as follows: Alpine zone to Labrador, southern Greenland and extreme north of Russia; Montane and Foothill zones to the region north of Lake Superior, Newfoundland, and the main part of Norway and Sweden. The plains zone to the Mississippi valley and the lowlands of Europe, except that the semi-arid climate gives some specialized features.

The Land and Fresh-water Crustacea of Colombia: A. S. Pearse. (Lantern slides.)

The Vertical Distribution of Some Plankton Protozoa in Wisconsin Lakes: Chancey Juday.

An Experimental Transmission of Sarcocystis Tenella: John W. Scott.

Exceptional Life-histories Among the Unionidæ: Arthur D. Howard.

Glochidia of a fresh-water mussel (Unionidæ) were found upon the external gills of *Necturus maculosus.* Eighty per cent. of the collections from the Mississippi were infected. By keeping the necturus alive from October to May the larval mussels were carried through the metamorphosis. The species was still unknown, as it did not correspond with any of the collection of glochidia available and which was supposed to be complete for the region. Study of the ranges of all reported forms revealed one rare species, *Hemilastena ambigua* Say, which might be the adult desired. Gravid mussels containing glochidia were found after considerable search late in September and a comparison with the glochidia in question removed all doubt that they were of the same species. The mussel has the unusual habit of living under flat stones of the flag-stone type. As *Necturus* is known to frequently seek such shelter, the manner of infection is explained.

Anodonta imbecillis has been reported by Sterki as normally hermaphroditic and by Howard as non-parasitic. The embryos have been observed within the egg-membrane up to the attainment of the juvenile stage. They were found to escape from the parental marsupium in late spring and their development followed to a growth of shell many times that of the original glochidium. Observations of the degree of development at various

seasons show a lack of agreement with conditions to be seen in most bradytictic or long period breeders. The following counts illustrate this:

Locality	Date	Eggs				Total
		Early Embryo	Late Embryo	Glochidia	Juveniles	
Moline, Ill...	November 7, 1913	7	3	7	5	22
Fairport, Ia..	May 1, 1914	2	1	5	6	14

Glochidia of *Strophitus edentulus* escaping at various times during the spring from the parent mussel were tested for reactions to sodium chloride, the blood of fishes and contact of fins. A closing reaction was seen in each case. This led to an attempt at normal infection with entire success. The juvenile stage was obtained after a parasitic period of 27 days on the black bass. We have failed, after studies covering two years, to observe development without parasitism in this species. It would seem, therefore, that non-parasitic development as reported for this species is exceptional.

The Isolation of the Okefinokee Swamp Islands, a Segregative or Convergent Factor in Species Formation: ALBERT H. WRIGHT.

The Reaction of Herring and Other Salt-water Fishes to Decomposition Products Normal to Sea-water: V. E. SHELFORD. (With lantern.)

Herring are very sensitive to hydrogen sulfide and carbon dioxide, dying very quickly in small quantities of the former and more quickly than fresh-water species in fatal concentrations of the latter. They turn back upon encountering hydrogen sulfide in sea water and react to hydrogen ions, selecting essential neutrality with a precision showing sensitiveness equal to litmus. When differences in acidity are present they do not react to differences in salinity and density. They react to differences in temperature as small as 0.2° C.

Some Results of the Indiana Lake Survey: WILL SCOTT.

Some Phenomena of Parasitism with Especial Reference to the Unionidæ: ARTHUR D. HOWARD.

The usual type of parasitism among the Unionidæ is little more than commensalism, apparently. The young mussel or glochidium is embedded in the epidermis of the host, where in the process of metamorphosis little besides protection and transportation are afforded. In addition to this common and intermediate condition we meet with two extremes; on the one hand, a pronounced dependence upon the host in which considerable growth of the parasite takes place as in the Proptera group. On the other, a complete loss of parasitism with independence of a host in which the glochidium remains in the maternal marsupium until the adult form is reached, as in *Anodonta imbecillis*. The existence of these extremes with intermediate gradations presents quite a range of conditions. The observation of loss of parasitism in *Anodonta imbecillis* brought up the question as to how far the normal appearing glochidia had lost the function for which their structure adapted them. Fresh-cut fins with the blood from live fishes were presented. The snapping reaction was obtained. Infection on fishes was tried without success until glochidia from a number of individuals were used. Infection with complete encystment was then secured. They were not carried beyond this stage.

The recognition of restricted parasitism among the Unionidæ has led to the discovery of some interesting ecological relationships, such as *Anodonta pustulosa* to the catfishes, *Quadrula ebenus*, to the herring; *Lampsilis anodontoides* to the grapikes, the Proptera group and the Plagiolas to the sheepshead.

The relationship between *Hemilastena ambigua* and *Necturus* is about the only case of which we have anything like a complete knowledge. The others mentioned are only a few of those known from hundreds of species of mussels the hosts of which are not known.

The elimination by fish of inappropriate mussel parasites is a phenomenon which we have often observed. The process seems to be one of catarrhal shedding of the external epithelial cells of the fish's gills. Such mechanisms of immunity raise the question as to the perhaps more wonderful adaptations seen in the persistence of the parasitic glochidium when it finds the appropriate host species.

Miscellaneous

Problems of Antarctic Bird Life: R. G. MURPHY.

Some Experiments on Protective Coloration: R. G. YOUNG.

The various theories of protective coloration are based on the assumption of the usefulness of such color. This has frequently been questioned, and lacks as yet adequate experimental support. In order to test the usefulness of color in protecting

animals from their enemies, a series of about 140 experiments, covering a period of six years, has been carried out with various species of caged, and in a few cases with wild birds, to which were fed several kinds of small mammals and insects. The latter were placed upon different backgrounds, with some of which they formed strong contrasts, while others they closely resembled. The birds were then allowed to choose between that prey which resembled, and that which contrasted with its background.

The experiments may be divided into two classes —those in which the birds usually approached their prey swiftly from a short distance, and those in which they approached it slowly, and seized it only after careful inspection. In the former class over 90 per cent. of the combinations chosen were contrasting, while in the latter, the contrasting combinations were chosen but little oftener than the non-contrasting ones.

The experiments indicate that the color of a motionless animal has a decided survival value when it is attacked by birds which approach it swiftly from a distance of even a few feet.

Immunity of Fowls to Cysticerci of Certain Cestodes: J. E. Ackert

Regeneration of Head Parts in Earthworms After Removal of the Anterior Portion of the Digestive Tube: H. R. Hunt. (Introduced by Herbert W. Rand.)

The object of these experiments was to determine whether the brain and commissures could be regenerated and the stomodeum formed in regenerating earthworms in the absence of the anterior end of the digestive tube. The first three anterior segments of the worms were removed and the digestive tube carefully removed from the first five or six segments posterior to the point where the head was cut off. One hundred and seventy-seven individuals of *Eisenia fœtida* and thirty-two individuals of *Helodrilas calliginosus* were used. Seventy-eight worms survived. In six specimens head parts regenerated when the anterior end of the digestive tube was three to five segment lengths from the anterior end of the worm. The six worms fall into three classes: in the first class a stomodeum was formed; in the second class a brain fundament and commissures were regenerated; in the third class a brain fundament and commissures regenerated and a stomodeum was formed.

I am indebted to Professor H. W. Rand, of Harvard University, for many helpful suggestions.

An Interesting Snail from Minnesota and a Problem in Geographical Distribution: R. W. H. Wolcott.

Exhibits

During the meeting the following exhibits were made in one of the rooms of the Zoological Laboratory of the University of Pennsylvania:

Exhibits and Demonstrations

Franklin D. Barker: The Absence of Male Reproductive Organs in Trematodes.

J. W. Mavor: The Larval and Post-larval Development of the Coral, *Agaricia Fragilis*, Dana.

Chester H. Heuser: Drawings and Models of the Stomachs of Embryo Cat, Albino Rat, Pig and Sheep.

E. J. Werber: Demonstrations of Some Sectioned and Unsectioned Material of Monstrous Embryos of Fundulus.

Harold S. Colton: Methods Used in Producing Changes Within Pure Lines of the Pond Snail, *Lymnæa.* (Room 104, Zoological Laboratory.)

T. H. Morgan, A. H. Sturtevant, C. B. Bridges and H. Muller: Demonstration of the Four Hereditary Groups and the Four Pairs of Chromosomes of *Drosophila.*

S. O. Mast: Autochromes from Life Showing Adaptation in Color in Flounders.

Caswell Grave,
Secretary-treasurer, American Society of Zoologists

SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

The one hundred and seventy-fifth regular meeting of the society was held at Columbia University on Saturday, February 27, 1915, with an attendance of 39 members at the two sessions. President E. W. Brown occupied the chair, being relieved by Vice-president Oswald Veblen at the afternoon session. The following persons were elected to membership: Professor J. V. Balch, Bethany College; Professor E. J. Berg, Union College; Mr. Millar Brainard, Chicago, Ill.; Mr. L. C. Cox, Purdue University; Mr. C. H. Forsyth, University of Michigan; Dr. H. C. Gossard, University of Oklahoma; Mr. M. S. Knebelman, Lehigh University; Dr. W. V. Lovitt, Purdue University; Dr. L. C. Mathewson, Dartmouth College; Mr. A. L. Miller, University of Michigan; Dr. Bessie I. Miller, Johns Hopkins University; Mr. I. R. Pounder, University of Toronto; Mr. L. L. Steimley, Indiana University; Mr. Chid-Cheow

Yen, Tangshan Engineering College. Three applications for membership were received.

The following papers were read at this meeting:

M. Fréchet: "Sur les fonctionnelles bilinéaires."

A. S. Hathaway: "Gamma coefficients."

P. H. Linehan: "Equilong invariants of irregular and regular analytic curves."

B. H. Camp: "Multiple integrals over infinite fields."

A. R. Schweitzer: "On the methods of mathematical discovery."

P. R. Rider: "An extension of Bliss's form of the problem of the calculus of variations, with applications to the generalization of angle."

E. B. Wilson: "The Ziwet-Field note on plane kinematics."

O. E. Glenn: "Ternary transvectant systems."

E. J. Miles: "Note on the application of the calculus of variations to a problem in mechanics."

A. B. Frizell: "The permutations of the natural numbers can not be well ordered."

C. H. Forsyth: "Osculatory interpolation formulas."

J. F. Ritt: "A function of a real variable with any desired derivatives at a point."

J. F. Ritt: "On Babbage's functional equation."

The next meetings of the society will be in Chicago, April 2–3, and New York, April 24. The summer meeting will be held at the University of California and Stanford University, August 3–5.

F. N. COLE,
Secretary

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 533d meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday, January 9, 1915. It was called to order by President Bartsch at 8 P.M. About 40 members were present.

The minutes of the 531st meeting were read and approved.

Waldo Schmitt, of the U. S. National Museum, was elected to active membership.

Under the heading Brief Notes and Exhibition of Specimens, Dr. L. O. Howard made remarks on the meetings held at Philadelphia during convocation week and Dr. Pilsbry discussed certain aspects of the Hawaiian land-shell problem. The latter said early collecting was done in the valleys, but recent work showed chief home of species to be on ridges. Distribution of forms occurred in groups and there were many instances of Mendelian inheritance between different forms carried out on large natural scale.

The first paper on the regular program was by Wm. Palmer: "An Unknown Fossil." Mr. Palmer exhibited the specimen from the Calvert Cliffs of Chesapeake Bay and hoped members would express views as to its nature. His own view was that it might represent the lower jaw of an unknown turtle. From the same locality other fossils were shown that had previously proved very difficult to identify. Mr. Palmer's communication was discussed by Professor Hay.

The second paper was by Professor Hay: "An Albino Terrapin." The unique specimen was exhibited; it was hatched near Beaufort, N. C.; an attempt was made to raise it, but it lived only a few months. Professor Hay took occasion to show excellent lantern slides of certain interesting crustaceans, especially of *Limnoria lignorum*, wood-boring Isopod, and of *Xylotria*, a wood-boring mollusk. Professor Hay's communication was discussed by Messrs. Bartsch, Wilcox, Palmer, Smith, Hopkins and by Miss Rathbun.

The last communication was by M. W. Lyon, Jr.: "Notes on the Physiology of Bats." The speaker stated little was known of exact physiology of bats, but discussed subject from broad standpoint of their physiology of locomotion, of food, adaptation and of special senses. Need of careful experiments on use of, and modern histological work on structure of nose leaves was pointed out. Paper was discussed by Messrs. Howard, Bishop, Hunter, Palmer and Stiles; Mr. Bishop giving an account of a bat roost near San Antonio, Texas, erected with the idea that bats would consume large numbers of malarial mosquitoes, Mr. Hunter stating that an examination of stomach contents of bats showed food of *Nytinomus mexicanus* consisted of 95 per cent. moths, the rest being carabid beetles, hymenopterous insects and a few crane flies, the only Diptera found, no mosquitoes being observed.

ON Tuesday, January 19, 1915, at 8:30 P.M., the Biological Society held a joint meeting with the Washington Academy of Sciences in the auditorium of the National Museum. Dr. Johan Hjort, Director of Fisheries of Norway, delivered an illustrated lecture on "Migrations and Fluctuations of the Marine Animals of Western Europe." About 200 persons were present.

The 534th meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, January 23, 1915, with President Bartsch in the chair and 75 persons present.

Mr. R. A. Ward was elected to active membership.

Under heading Brief Notes, etc., Dr. Johan Hjort, Director of Fisheries of Norway, called attention to the large numbers of herring caught in Norwegian waters during the last few years, most of them belonging to what he termed the "1904 Class." Dr. Hjort attributed the great success of the "1904 Class" to the known lateness of season when it had been spawned and when the plankton was abundant. Early in spring the sea is practically barren of plankton and fish hatching at that time have little food.

The regular program was an illustrated paper by Mrs. Agnes Chase on "Developing Instincts of a Young Squirrel." Mrs. Chase had made careful observations and notes on the bringing up of a young gray squirrel during the past spring and summer. The animal was very young when first acquired by the speaker, needing to be fed on milk with a medicine dropper. Mrs. Chase described its growth, acquisition of squirrel-like habits and instincts. It was not brought up as a pet, but was given every freedom to develop its natural traits. At maturity it met with wild members of its own species, at first returned home, but finally remained away. Mrs. Chase had a few records of the squirrel after it had left; at one time it was seen in company with seven wild squirrels in a strawberry patch where it had once learned to feed. Wild squirrels had not been seen in this patch before and the speaker concluded they had been taught to eat strawberries and shown the place by her former pet.

The rest of the evening was given over to an exhibition of lantern slides on biological subjects. W. W. Cooke showed views of bird life; Dr. Smith, of Japanese silk industry; Wm. Palmer, of seals and birds of Pribilof Islands; Dr. Bartsch, of local birds.

M. W. Lyon, Jr.,
Recording Secretary

The New Orleans Academy of Sciences

The regular monthly meeting of the New Orleans Academy of Sciences was held at Tulane University on Tuesday, January 19. In the absence of the President, Dr. Irving Hardesty presided. Two papers were presented at the meeting, the first by Dr. W. O. Scroggs, of the history department of Louisiana State University, on "The Mosquito Kingdom and Henry L. Kinney." According to Dr. Scroggs:

Early in the nineteenth century agents of Great Britain on the Mosquito coast, in eastern Nicaragua, persuaded the native chiefs in this region to recognize one of their number as king, and this half-breed sovereign was persuaded in turn to place his realms under the protection of the British Crown. In the United States it was feared that the British claims thus set up would prove an obstacle to the construction of the interoceanic canal. The Mosquito king meanwhile had made vast grants of his land to enterprising traders along the coast, and these concessions were bought up by an American adventurer, Henry L. Kinney, who undertook in 1855 to colonize the Mosquito coast with Americans and counteract British influences. Kinney's plans were laid on an elaborate scale, but he encountered such opposition from a syndicate of American capitalists at home and from a rival adventurer in Nicaragua, William Walker, that the enterprise failed, and he was financially ruined.

The second paper was by Dr. Gustav Mann, professor of physiology, Tulane University: "What part does water play in our economy?"

Dr. Mann discussed water metabolism. After a general survey of the total quantity of water in individuals of different ages and of that for individual tissues the absorption of water by the intestines, its storage especially in the muscles and its formation inside the body as a result of oxidation of fats, sugars and proteins was gone into. Then the advantages of the circulation of water within the body, the elimination by the salivary glands, the stomach and the intestines and re-absorption of water along with dissolved food substances was pointed out. The work done by Hawk along with Mattill and Hattrem was criticized. There can not be any doubt that an absorption of 4 to 5 liters of water per day greatly helps the digestion of carbohydrates, fats and proteins. It is necessary, however, to constantly bear in mind the amount of salt which is taken with the food. The effect which an excess of salt produces is to render the globulins of the body more soluble while large quantities of water produce the opposite effect. The great advantage of giving nutritive solutions hypodermically and thereby insuring a slow absorption of food radicals in contradistinction to giving salt solutions intravenously for purposes of raising blood pressure was explained. When talking about the elimination of water by the skin, lungs and kidney, the advantage of breathing through the nose and thus keeping the air passages moist to allow foreign material to be caught in the nasal passages was emphasized.

Both papers were the subject of considerable discussion. At the conclusion of the papers, Dr. Mann made an exhibit of brain and thalamus dissections made permanent by infiltration with solid paraffin.

R. S. Cocks,
Secretary